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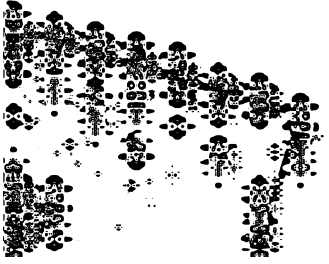
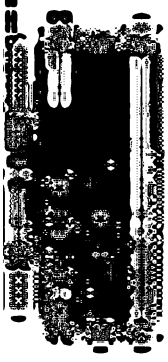
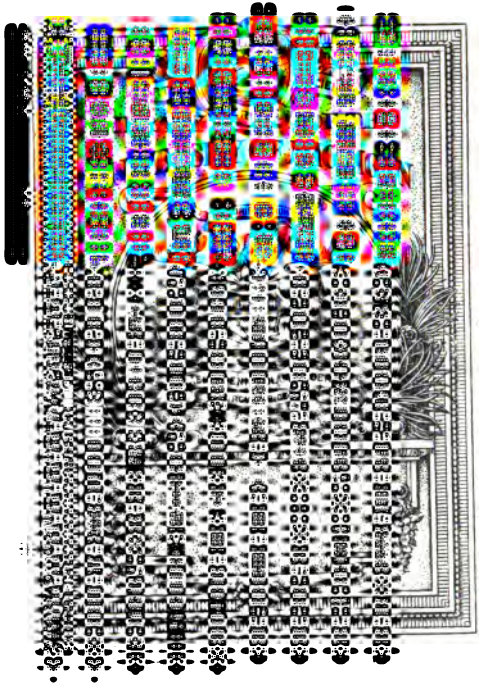
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CHEMICAL EXPERIMENTS

GENERAL AND ANALYTICAL

FOR USE WITH ANY TEXT-BOOK OF CHEMISTRY, OR
WITHOUT A TEXT-BOOK

BY

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BOSTON, U.S.A., AND LONDON
PUBLISHED BY GINN & COMPANY
1895

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PREFACE.

THE rapid growth of the laboratory method of teaching chemistry since the author's *Manual* was issued in 1888 has called for a larger and more comprehensive work of a similar sort for high schools, academies, and colleges. To such a call the present book is a response.

In preparing the experiments the author has endeavored, *first*, to select such as are most instructive and best illustrate the subject without being too elaborate; *second*, to arrange them in an order calculated to lead up by the most natural and easiest steps to a knowledge of the science; *third*, to make the subject fascinating by giving just enough information and suggestion to interest the experimenter, and to make him work for the knowledge to be gained. Finally, the author has aimed to make the book simple enough for the dull and slow pupil, and — by the introduction of supplementary and original work — elaborate enough for the most acute. Great care has been taken to give minute and accurate directions for performing the experiments. "Terms" at the end of experiments are for pupils to study outside the laboratory, and are often repeated. They may also be discussed in the laboratory.

Metal analysis has received a somewhat unique treatment. Each metal of a group is first taken separately, and the *analytical* reactions are given. This method shows the pupil at once why a given re-agent is added, and what its effect is. The product is given when the substance is in solution as well as when it is precipitated. The group is next treated in the same way. This method clarifies the subject greatly in the pupil's mind, and is believed to be a valuable departure in teaching analysis.

The new orthography recommended by the Chemical Section of the A. A. A. S. has been adopted, as a step towards uniformity and progress.

It is recommended that wherever it is possible each laboratory period cover the space of two hours (even if there can be only one period per week), and that the last 20 or 30 minutes be taken to question the class rapidly on the work of the day, discuss and explain the use of terms, etc. The books should be inspected after each exercise, or perhaps after each experiment has been written out.

It is by no means necessary to perform every experiment, or to follow the order here given, if the teacher prefers to do otherwise. A diversity of opinion exists among teachers, and a diversity of time and talent among pupils and classes. In no place better than in the laboratory, under a competent instructor, can a "cast-iron rule" be done away with, and variety of arrangement and method be adopted.

The author would be glad to receive criticisms, as well as suggestions as to other methods, or experiments, or different ways of performing experiments. Especially would he be glad to know what it has been difficult, in the matter of directions or principles, for pupils to understand.

The author desires to acknowledge valuable suggestions in the preparation of this work from the following persons: Messrs. J. Y. Bergen, Jr., C. W. Gerould, E. F. Holden, A. S. Perkins, N. S. French, H. I. Lord, E. S. Chapin; and Misses D. M. Stickney, M. L. Foster, and others.

CAMBRIDGE,

December 1, 1895.

INDIVIDUAL APPARATUS.

Each pupil should be provided with the apparatus given below, but in cases where great economy must be exercised different pupils may, by working at different times, use the same set. The author has selected apparatus specially adapted, as to exact dimensions, quality, and cheapness, for performing in the best way the experiments herein described, and sets or separate pieces of this, together with other apparatus and chemicals, can be had of the L. E. Knott Apparatus Co., 14 Ashburton Place, Boston, to which firm teachers are referred for catalogs.

4 re-agent bottles, 250 cc. glass stoppers, blown labels: NH_4OH , HCl , HNO_3 , H_2SO_4 .	1 camel's-hair brush.
1 pneumatic trough.	1 magnet.
1 Hessian crucible.	4 wide-mouthed bottles.
2 beakers.	1 2-holed rubber stopper to fit above.
2 pieces wire gauze.	4 pieces window-glass.
1 piece platinum wire.	1 glass funnel.
1 mouth blowpipe.	1 porcelain evap. dish.
6 pieces glass tubing.	1 asbestos board.
4 pieces hard glass tubing.	1 sand bath.
1 test-tube brush.	1 pair iron forceps.
1 small tube brush.	1 triangular file.
1 doz. test tubes.	1 round file.
4 cork stoppers, for tubes.	1 piece copper wire.
1 fish-tail attachment for Bunsen burner.	1 piece lead wire.
1 blowpipe attachment with rest for Bunsen burner.	1 piece zinc wire.
1 piece sheet copper.	1 wooden test-tube holder.
1 glass retort.	1 wire test-tube rack.
1 tumbler.	1 thistle tube.
1 piece cobalt glass.	1 Bohemian flask.
1 horn spatula.	1 2-holed rubber stopper to fit flask.
1 sheet litmus paper.	1 Bunsen burner.
200 filter papers.	1 iron ring stand.
1 bunch splints.	2 ft. rubber tubing.
1 sheet turmeric paper.	1 ft. " "
	1 metric ruler.
	1 graduate.
	1 small leaden dish.

GENERAL APPARATUS.

The requirements of general apparatus for a laboratory are too numerous and varied to be given here. A few of the pieces in more general demand for experiments in this book are as follows:

Glass-stoppered bottles.	Filter-stands.
Graduates.	Glass and rubber tubing.
Funnels.	Steel glass-cutters.
Fruit jars (for making solutions).	Steel wire-cutters.
Scales, with metric weights.	Mortars and pestles.
Ignition tubes.	Flasks.
Beakers.	Filter papers, etc., etc.

CHEMICALS.

ESTIMATE FOR A CLASS OF TWENTY IN GENERAL CHEMISTRY AND ANALYTICAL REACTIONS, NOT INCLUDING GENERAL REACTIONS AND SUPPLEMENTARY WORK.

Acid, acetic, $\text{HC}_2\text{H}_3\text{O}_2$	4 lb.	Arsenopyrite, FeAsS	$\frac{1}{2}$ lb.
“ boric, H_3BO_3	$\frac{1}{2}$ “	Barium chlorid, BaCl_2	$\frac{1}{2}$ “
“ hydrochloric, HCl	25 “	“ hydroxid, $\text{Ba}(\text{OH})_2$	$\frac{1}{2}$ “
“ hydrofluoric, HF	$\frac{1}{2}$ “	Bismuth oxychlorid, BiOCl	$\frac{1}{2}$ “
“ hydrofluosilicic, H_2SiF_6	$\frac{1}{2}$ “	Calcium chlorid, CaCl_2	$\frac{1}{2}$ “
“ nitric, HNO_3	12 “	“ fluorid, powdered, CaF_2	$\frac{1}{2}$ “
“ oxalic, $\text{H}_2\text{C}_2\text{O}_4$	$\frac{1}{2}$ “	“ hypochlorite, CaCl_2O	$\frac{1}{2}$ “
“ phosphoric, H_3PO_4	$\frac{1}{2}$ “	“ sulfate, CaSO_4	$\frac{1}{2}$ “
“ sulfuric, H_2SO_4	18 “	“ oxid, CaO	2 “
“ tartaric, $\text{H}_2\text{C}_4\text{H}_4\text{O}_6$	$\frac{1}{2}$ “	Carbon bisulfid, CS_2	$\frac{1}{2}$ “
Alcohol, $\text{C}_2\text{H}_5\text{OH}$	1 qt.	Charcoal, animal, gran., C	1 “
Alum, $\text{K}_2\text{Al}_2(\text{SO}_4)_4$	1 lb.	“ “ powdered, C	1 “
Aluminum chlorid, AlCl_3	$\frac{1}{2}$ “	“ wood, “ C	1 “
Ammonium carbon., $(\text{NH}_4)_2\text{CO}_3$	1 “	“ “ C	20 pieces
“ chlorid, NH_4Cl	2 “	Cobalt chlorid, CoCl_2	$\frac{1}{2}$ lb.
“ hydroxid, NH_4OH	20 “	“ nitrate, $\text{Co}(\text{NO}_3)_2$	$\frac{1}{2}$ “
“ nitrate, NH_4NO_3	1 “	Cochineal.....	$\frac{1}{2}$ “
“ oxalate, $(\text{NH}_4)_2\text{C}_2\text{O}_4$	$\frac{1}{2}$ “	Copper, turnings, Cu	3 “
“ sulfate, $(\text{NH}_4)_2\text{SO}_4$	$\frac{1}{2}$ “	“ sheet, Cu	$\frac{1}{2}$ “
Antimony cryst., Sb	$\frac{1}{2}$ “	“ chlorid, CuCl_2	1 “
“ chlorid, SbCl_3	$\frac{1}{2}$ “	“ nitrate, $\text{Cu}(\text{NO}_3)_2$	$\frac{1}{2}$ “
Arsenious oxid, As_2O_3	1 oz.	“ oxid, CuO	1 “

Copper sulfate, CuSO_4	$\frac{1}{2}$ lb.	Potassium, dichromate, $\text{K}_2\text{Cr}_2\text{O}_7$	1 lb.
Ether, $(\text{C}_2\text{H}_5)_2\text{O}$	$\frac{1}{2}$ "	" ferrocy., $\text{K}_4\text{Fe}(\text{CN})_6$	1 "
Gold leaf, Au.....	1 bk.	" ferricy., $\text{K}_3\text{Fe}(\text{CN})_6$	$\frac{1}{2}$ "
Indigo.....	$\frac{1}{2}$ lb.	" iodid, KI.....	1 "
Iodin, I.....	2 oz.	" hydroxid, KOH.....	1 "
Iron, fine turnings, Fe.....	1 lb.	" nitrate, KNO_3	1 "
" by hydrogen, Fe.....	$\frac{1}{2}$ "	" nitrite, KNO_2	$\frac{1}{2}$ "
" perchlorid, FeCl_3	1 "	" permangan., KMnO_4	$\frac{1}{2}$ "
" protosulfid, FeS	5 "	" sulfocyanid, KSCN	$\frac{1}{2}$ "
" pyrite, FeS_2	$\frac{1}{2}$ "	" tartrate, $\text{K}_2\text{C}_4\text{H}_4\text{O}_6$	$\frac{1}{2}$ "
" sulfate, FeSO_4	1 "	Silica, powdered, SiO_2	$\frac{1}{2}$ "
Lead, sheet, Pb.....	1 "	Silver nitrate, AgNO_3	4 oz.
" wire, $\frac{1}{8}$ in. diam., Pb.....	12 ft.	Sodium, metallic, Na.....	$\frac{1}{2}$ "
" acetate, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$	$\frac{1}{2}$ lb.	" acetate, $\text{NaC}_2\text{H}_3\text{O}_2$	$\frac{1}{2}$ lb.
" chlorid, PbCl_2	$\frac{1}{2}$ "	" arsenite, HNa_2AsO_3	$\frac{1}{2}$ "
" nitrate, $\text{Pb}(\text{NO}_3)_2$	2 "	" bicarbonate, HNaCO_3	$\frac{1}{2}$ "
" protoxid, PbO	$\frac{1}{2}$ "	" bisulfate, HNaSO_4	$\frac{1}{2}$ "
" tetroxid (red), Pb_3O_4	$\frac{1}{2}$ "	" borate, $\text{Na}_2\text{B}_4\text{O}_7$	$\frac{1}{2}$ "
Litmus, cubes.....	1 oz.	" carbonate, Na_2CO_3	3 "
Marble chips, CaCO_3	3 lb.	" chlorid, NaCl.....	4 "
Magnesium ribbon, Mg.....	10 ft.	" hydroxid (caust.), NaOH.....	3 "
" chlorid, MgCl_2	$\frac{1}{2}$ lb.	" nitrate, NaNO_3	2 "
" sulfate, MgSO_4	$\frac{1}{2}$ "	" nitrite, NaNO_2	$\frac{1}{2}$ "
Manganese chlorid, MnCl_2	$\frac{1}{2}$ "	" oxalate, $\text{Na}_2\text{C}_2\text{O}_4$	$\frac{1}{2}$ "
" dioxid, gran., MnO_2	$\frac{1}{2}$ "	" phosphate, HNa_2PO_4	1 "
" " powd., MnO_2	$\frac{1}{2}$ "	" sulfate, Na_2SO_4	1 "
Mercury, Hg.....	$\frac{1}{2}$ "	" sulfid, Na_2S	$\frac{1}{2}$ "
" bichlorid, HgCl_2	$\frac{1}{2}$ "	" sulfite, Na_2SO_3	$\frac{1}{2}$ "
" protochlorid, HgCl	$\frac{1}{2}$ "	" thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$	1 "
" pernitrate, $\text{Hg}(\text{NO}_3)_2$	$\frac{1}{2}$ "	Starch, $\text{C}_6\text{H}_{10}\text{O}_5$	$\frac{1}{2}$ "
" protonitrate, HgNO_3	$\frac{1}{2}$ "	Strontium chlorid, SrCl_2	$\frac{1}{2}$ "
" oxid, HgO	1 "	Sugar, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$	1 "
Nessler's sol.....	$\frac{1}{2}$ "	Sulfur, brimstone, S.....	2 "
Phosphorus, P.....	2 oz.	" flowers, S.....	1 "
Picture wire.....	1 roll	Tin bichlorid, SnCl_2	$\frac{1}{2}$ "
Platinum chlorid, sol., PtCl_4	1 oz.	Turmeric paper.....	1 sheet
Potassium, metallic, K.....	$\frac{1}{2}$ "	Turpentine, $\text{C}_{10}\text{H}_{16}$	1 oz.
" bromid, KBr.....	$\frac{1}{2}$ lb.	Zinc, gran., Zn.....	3 lb.
" carbonate, K_2CO_3	$\frac{1}{2}$ "	" wire, $\frac{1}{8}$ in. diam.....	12 ft.
" chlorid, KI.....	$\frac{1}{2}$ "	" (arsenic-free).....	1 lb.
" chlorate, KClO_3	2 "	" chlorid, ZnCl_2	$\frac{1}{2}$ "
" chromate, K_2CrO_4	$\frac{1}{2}$ "	" nitrate, $\text{Zn}(\text{NO}_3)_2$	$\frac{1}{2}$ "
" cyanid, KCN.....	$\frac{1}{2}$ "	" Litmus paper.....	$\frac{1}{2}$ quire

SOLUTIONS, Etc.

In making solutions for metal analysis, chlorids of the metals are usually taken (except in Group I, in which nitrates are used, the chlorids being insoluble). From 25% to 50% of solids are usually dissolved in 500^{cc} of distilled water, and filtered if necessary. Many are sat., as $\text{Ca}(\text{OH})_2$. Substances for analysis, as well as acids and other re-agents, should be C. P. Concentrated acids are used unless the dilute are called for.

A few exceptional sols. are given below :

HNa_2PO_4 , 40.	$(\text{NH}_4)_2\text{CO}_3$, 100.	$(\text{NH}_4)_2\text{SO}_4$, 5.
KCy, 50.	KNO_3 , 50.	NH_4Cl , 60.
$\text{K}_2\text{Cr}_2\text{O}_7$, 25.	KOH, 60.	NaOH, 60.

Dilute acids are made by mixing one volume of concentrated acid with four volumes of water.

NH_4OH . If NH_4OH of 26° is obtained, it should be diluted with three times its volume of water before using.

HgNO_3 is best prepared by putting into a large e.d. say 25% of Hg, and adding to it a mixture of 25^{cc} HNO_3 and 25^{cc} of H_2O , and letting it stand till action stops, then adding 400^{cc} or 500^{cc} of H_2O . More Hg should be used than will dissolve, and some should be left in the bottle.

PbCl_2 is only slightly soluble in water. A saturated sol. should be used.

BiCl_3 is prepared by adding water and HCl to oxychlorid of bismuth, BiOCl . First add the H_2O , then acidulate it with the acid, say 1 vol. of HCl to 20 of H_2O , it being insol. in H_2O alone.

AsCl_3 . Add H_2O to sodium arsenite HNa_2AsO_3 , then add HCl with stirring till effervescence stops.

SbCl_3 . Pour a little butter of antimony, SbCl_3 , into H_2O , then acidulate with HCl.

SnCl_2 . This must also be acidulated with HCl, and a little Sn should be left in the bottom of the bottle.

CrCl_3 . This may be made from $\text{K}_2\text{Cr}_2\text{O}_7$ sol. by adding some HCl (say $\frac{1}{10}$) and a little alcohol, boiling some time and letting it stand, when it turns from red to green.

$(\text{NH}_4)_2\text{S}$. Pass H_2S gas into dilute NH_4OH till the sol. gives no ppt. with MgSO_4 sol., then filter. It should be nearly colorless.

$(\text{NH}_4)_2\text{S}_x$ (ammonium polysulfid). Stir sulfur flowers in the $(\text{NH}_4)_2\text{S}$, as above prepared, then filter. It is yellow.

Cochineal sol. Grind up a handful of cochineal in a mortar, and add water, stir, and filter.

Litmus sol. Pulverize litmus cubes, and add water.

Indigo sol. (sulfindigotic acid). Slowly mix and stir 5% indigo with 25^{cc} H_2SO_4 (or better $\text{H}_2\text{S}_2\text{O}_7$, fuming sulfuric acid) in a beaker immersed in cold water. Cover the beaker, and after 48 hours add 500^{cc} H_2O , stir and filter.

Many substances in sol. easily break up on standing, and hence should be freshly prepared.

For acid radicals compounds of Na or K are commonly used, as they are soluble.

RULES AND SUGGESTIONS FOR PUPILS.

Pupils should read these rules carefully, and should refer to them whenever in doubt on any point.

1. Each pupil should provide himself with a towel, to keep his bench clean, and any apron or other clothing desired for protection in the laboratory. A long linen duster or duck coat reaching to the feet is the best protection. Without something of the sort clothing may be injured at any moment.

2. The bench at which the pupil works must be left *clean and dry* after every laboratory exercise. Wipe off a ring-stand, lamp, or other apparatus on which a re-agent has fallen, wipe out a p.t. after using it, and keep re-agent bottles, apparatus, books, and lockers clean.

3. Pupils are held responsible for apparatus, and should replace anything that is lost or broken.

4. In experimenting have your apparatus neatly arranged without artificial props, wedges, or uncouth-looking material. Have every d.t. and stopper fit tightly to prevent leakage of gas. If a gas generates well, but does not pass into the rec., there is some leakage, due probably to loose bearings.

5. In heating a t.t. on the r.s. hold the lamp in the hand, move it slowly, and now and then take it away from the tube for a moment, to prevent melting and breaking the latter.

6. Mixtures of solids should be made on paper. *Be careful not to mix chemicals or re-agents except as directed.*

7. To shake the contents of a t.t. cover its mouth with the thumb (Exp. 4, Fig. 10), or the hand, or a stopper, *hold it away from the bench*, and shake it vigorously.

8. Never put down a stopper when using a re-agent bottle, but hold it between the first and second fingers (Exp. 6, Fig. 11), and replace it when you put down the bottle. Do not pour back any excess of a re-agent from a t.t. or other rec. into a re-agent bottle, and do not dip a stirring rod into a re-agent bottle.

9. In pouring a liquid into a t.t. (or graduate) hold the latter on a level with the eye, and towards the light, so as to see any change. The thumb-nail may be placed at the upper limit to which it is desired the liquid should reach. When much heat is liberated, as when sulfuric acid is poured into water, a tube-holder should be used; paper folded several times serves for this purpose.

10. Pour only liquids, fine powders, or soluble salts into the sinks, *always opening the faucet first to let the water run*. Other solids should be thrown into the jars. *Great care must be taken not to clog the discharge-pipes.*

11. Have flasks and tubes perfectly dry on the outside before applying heat. Tubes of thick glass, if they contain no liquid, should be heated gradually at

first by moving them alternately into and out of the flame. Before lighting the gas of a Bunsen burner, open the jet to its full capacity. If the gas "burns at the base," extinguish and re-light it.

12. Re-agents for general use must not be taken to the individual's bench, but left at the side-table, and nothing must be put into a pupil's locker except what belongs there.

13. The pupil should, before entering the laboratory, make as thorough preparation for experimenting, by studying a text-book, as he would for a recitation. In experimenting follow the directions as closely as possible. Read an exp. through before performing any part of it. *Ask an explanation of anything you do not understand. Observe very carefully everything that takes place, and try to ascertain what is important in the experiment. Note especially the order in which phenomena occur.*

14. Read several times the "Model for taking Notes." Begin to write on the page opposite the experiment. Both name and symbolize substances once in each exp., as "Manganese dioxid, MnO_2 "; afterwards in the same exp. use either name or symbol. In writing equations employ only symbols, without names or weights. Indicate gases in equations by a bracket above the symbol, as $\widetilde{\text{NH}_3}$; ppts. by a bracket beneath, as PbCl_2 .

15. In memorizing experiments learn the names, symbols, processes, and products, but not the quantities of chemicals used.

16. Make a special point of keeping a neat, accurate, and full record of your observations, and what they teach, but do not write in your notes irrelevant matter which may have been read in the text-book, but which the experiment does not show, except in certain cases for explanation.

17. No notes should be written in this book outside of the laboratory without special permission. Note-books should be left in the laboratory at the end of the hour, and no other books should be used in connection with the experiments.

18. Write your name and the division to which you belong distinctly across the front edge of the book in Roman letters. Books should be covered with heavy paper.

19. For burns put some Na_2CO_3 (dried) or HNaCO_3 on a handkerchief, moisten it, and bind it on the part affected. If this is done in season no blister will form, and the pain will soon cease.

TAKING NOTES.

It is of the greatest importance that pupils should make accurate observations, and take correct and original notes.

These notes should embody the following points, and no experiment should be accepted unless it does contain them : 1. CHEMICALS (names and symbols); 2. APPARATUS, ADJUSTMENT, etc.; 3. OBSERVATIONS and RESULTS, such as the state (solid, liquid, or gaseous) of the product, its color, odor (if a gas), increase of temperature, etc.; 4. EXPLANATION of each change, with equation wherever that is possible. 1, 2, should be stated very briefly, not in separate parts, but as in the model below, and without copying from the page of directions. The main stress should be put on 3 and 4. Questions, calls for observations, equations, etc., in the directions are suggestive only, and not intended to indicate the complete notes. Methods vary, but the author prefers a plan similar to that outlined below. If this is followed, pupils must study the model carefully. The author has a brief and accurate method for recording Metal Analysis, which he will be glad to indicate to any teacher desiring it.

MODEL FOR NOTES.

PREPARATION OF OXYGEN.

I mixed about 5g of white crystalline potassium chlorate, KClO_3 , with not quite as much black, powdered manganese dioxid, MnO_2 , put the mixture into a t.t., adjusted a d.t., hung it to a r.s., and arranged so as to collect the gas in recs. over water in a p.t. I applied heat moderately at first, and afterwards more strongly.

I noticed the water in the d.t. began to move forward, as if pushed by a gas, and soon bubbles rose to the top of the rec. These became larger, and rose more rapidly as the heat increased. They gradually drove the water out of the rec. As they burst they threw off a fine gray cloud, which I decided was a solid, as it soon settled, beginning to disappear at the top first. It may have been very fine MnO_2 , etc., carried over mechanically in the bubbles of oxygen. An almost colorless gas remained. On heating the mixture in the tube I also noticed slight explosions which threw up particles of MnO_2 . These seemed to be caused by the rapid separation of the gas under the MnO_2 . The equation which stands for the reaction is



Every molecule of solid potassium chlorate breaks up into a molecule of solid potassium chlorid and 3 atoms of gaseous oxygen. The O, occupying much volume, escapes through the d.t.

At the end of the experiment there is in the t.t....., etc.

The back action in the d.t. is caused by....., etc.

TABLE OF COMMON ELEMENTS.

ARRANGED ACCORDING TO ELECTRO-CHEMICAL ORDER.

	NAME.	SYMBOL.	AT. WT.	VAPOR DENSITY.	STATE.
Negative or Non-Metallic Elements. Acid-Forming with H (usually OH).	Oxygen	O''	16	16	G
	Sulfur	S'', ^{iv} (vi)	32	32	S
	Nitrogen	N''', ^v , etc.	14	14	G
	Fluorin	F', (v)	19		G
	Chlorin	Cl', (v)	35.5	35.5	G
	Bromin	Br', (v)	80	80	L
	Iodin	I', (v)	127	127	S
	Phosphorus	P'', ^v	31	62	S
	Arsenic	As'', ^v	75	150	S
	Chromium	Cr'', ^{'''} , ^{vi}	52		S
	Boron	B''	11		S
	Carbon	C'', ^{iv}	12		S
	Antimony	Sb'', ^v	120		S
	Silicon	Si''	28		S
	Hydrogen	H'	1	1	G
	Gold	Au', ^{'''}	197		S
	Platinum	Pt', ^{iv}	197		S
	Mercury	Hg', "	200	100	L
	Silver	Ag'	108		S
Positive or Metallic Elements. Base-Forming with OH.	Copper	Cu', "	63		S
	Bismuth	Bi'', (v)	207		S
	Tin	Sn'', ^{iv}	117		S
	Cadmium	Cd''	112	56	S
	Cobalt	Co'', (''')	59		S
	Nickel	Ni'', (''')	58		S
	Lead	Pb'', ^(iv)	206		S
	Iron	Fe'', ^{'''}	56		S
	Zinc	Zn''	65	32½	S
	Manganese	Mn'', (''')	55		S
	Aluminum	Al''	27		S
	Magnesium	Mg''	24		S
	Calcium	Ca''	40		S
	Strontium	Sr''	87		S
	Barium	Ba''	137		S
	Sodium	Na'	23		S
	Potassium	K'	39		S

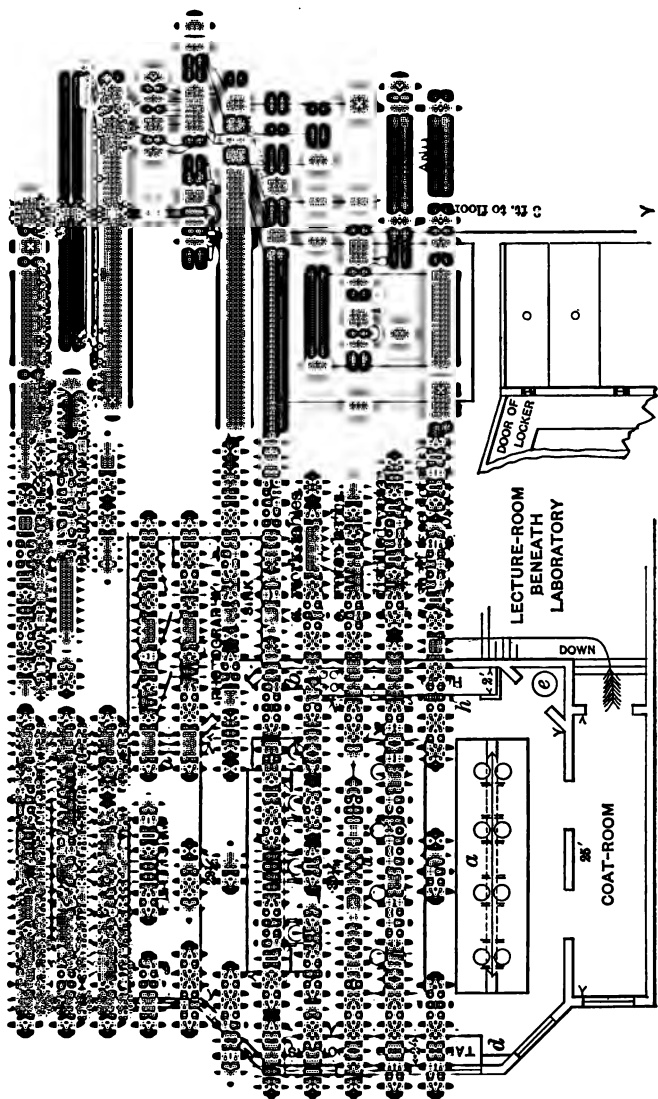
A () indicates a rare valence. Atomic weights are only approximate.

ABBREVIATIONS.

Ac. — acetate, $C_2H_3O_2$.	gr. — green.
alk. — alkali or alkaline.	insol. — insoluble.
Am. — ammonium, NH_4 .	i. t. — ignition tube.
app. — apparatus.	M. — metal (valence 1).
• b. — black.	o. f. — oxidizing flame.
B.B. — before the blowpipe.	Ox. — oxalate.
B.B.C.C. — before the blowpipe on charcoal.	ppd. — precipitated.
bl. — blue.	ppg. — precipitating.
cc. — cubic centimeters.	ppn. — precipitation.
cm. — centimeters.	ppt. — precipitate.
col. — color.	p. t. — pneumatic trough.
conc. — concentrated.	qcm. — square centimeters.
cpd. — compound.	re-agt. — re-agent.
cryst. — crystalline.	rec. — receiver.
Cy. — cyanid, CN.	res. — residue.
dil. — dilute.	r. f. — reducing flame.
dis. — dissolve.	r. s. — ring stand.
dist. — distinguish.	sat. — saturate.
d. s. — deflagrating spoon.	sep. — separate.
d. t. — delivery tube.	sl. — slight or slightly.
e. d. — evaporating dish.	sol. — solution or soluble.
evap. — evaporate.	sp. gr. — specific gravity.
ex. — excess.	s. r. — stirring rod.
Exp. — experiment.	Tr. — tartrate.
fil. — filtrate.	t. t. — test tube.
g. — grams.	up. disp. — upward displacement.
gel. — gelatinous.	v. — <i>vide</i> , see.
gen. — generator.	vol. — volume.
	yel. — yellow.

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1. METRIC MEASUREMENTS.

I. Length.

Note the length of 10^{cm} on a metric ruler, then estimate by the eye alone this length on the cover of a book, and on various objects, verifying each result till you can carry in mind 10^{cm} . Estimate the number of inches it covers, and verify. In the same way experiment with 1^{cm} . Measure the perpendicular distance between the blue lines on a sheet of foolscap paper. Measure the diameter of the older nickel five-cent piece. Make a drawing of the following measurements on the opposite page: one square decimeter, *i.e.* 10^{cm} on a side; 1^{cm} .

II. Volume.

Measure in a graduate 10^{cc} of water, then pour it into a t.t. Note, without marking, what proportion of the t.t. is filled. Make a drawing of it on the opposite page. Pour out the water, then pour into the t.t. as near the same volume as possible, estimating by the eye alone. Verify the result by pouring the water into the graduate. Repeat this till you can estimate quite accurately. Try it with a t.t. of another size. Estimate 1^{cc} of the liquid in the same way. Draw a figure of a cube 1^{cm} on a side.

In future experiments *estimate volumes, without measuring*, unless special accuracy is required.

III. Weight.

Balance a piece of paper on each pan of a pair of scales. On one pan put a 10^{g} weight and balance this with fine salt or sugar. Note with the eye the quantity of the substance, then remove it. Now estimate a like quantity and verify by weighing it. Repeat the experiment several times. Weigh 1^{g} or 2^{g} and estimate as before. See if 1^{g} can be piled on a one-cent coin. Weigh one of the old nickel five-cent pieces. In subsequent experiments *estimate quantity of solids*, unless accuracy is desired.

Supplementary. — Commit to memory the metric tables for length, volume and weight (v. Physics). How many cc in a liter? How many grams should a liter of water weigh? 10^{cc} of water? Hg weighs 13.6 times as much as water. What will 54^{cc} of Hg weigh? A rectangular block of marble is $3 \times 4 \times 2^{\text{cm}}$ and has sp. gr. 2.5. What does it weigh in grams?



2. GLASS MANIPULATION.

I. Ignition Tubes.

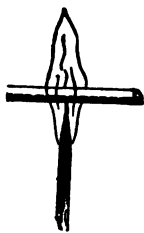


Fig. 1.

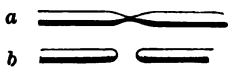


Fig. 2.

Take a piece of ignition tubing 20 or 25^{cm} long, hold it *steadily* in a Bunsen flame *just above the inner greenish cone* (Fig. 1), and rotate it. When it begins to soften draw it out slightly (Fig. 2, *a*) and raise it a little in the flame. Do not pull or twist the glass but let the heat gradually separate it, so as not to have long threads attached. The ends may be rounded (Fig. 2, *b*) by holding in the edge of the flame (Fig. 3). Finally anneal the glass by closing the lower open-

ings of the lamp and holding the heated end in the flame to cover it with soot, then letting it cool gradually without touching any object.

Unless great care is taken in this, the glass will break when next put into the flame. Save the tubes for subsequent experiments.

II. Stirring Rod.

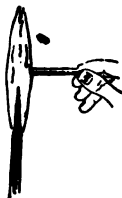


Fig. 3.

Weld the ends of a piece of glass tubing about 15^{cm} long and $\frac{1}{4}$ or $\frac{1}{2}$ ^{cm} in diameter by holding each end successively in a Bunsen flame above the green cone (Fig. 3), and rotating till the openings are sealed. Use care in cooling as before.

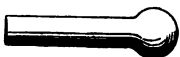


Fig. 4.

Supplementary. — Bulb Tubes. Draw out a piece of tubing as in 1, then melt the closed ends by holding and rotating as in Fig. 3. When the glass is sufficiently softened, blow moderately into the open end, repeating the operation till the tube assumes the desired shape (Fig. 4).

3. GLASS MANIPULATION.

III. Connecting Tubes.

Use an ordinary gas flame (or a fish-tail attachment to a Bunsen burner) for bending glass, as the Bunsen flame is too hot. Turn down the gas till the flame is about 5^{cm} across, then bend each of 3 pieces of tubing, 16^{cm} long, in the middle and at right angles, by letting the glass rest lightly in the fingers of both hands and holding it *lengthwise* of the flame and just above the dark part (Fig. 5). Rotate it *slowly* and hold *very steadily*. When it begins to soften take it quickly from the flame and — holding it between the eye and a window frame — bend it at right angles.

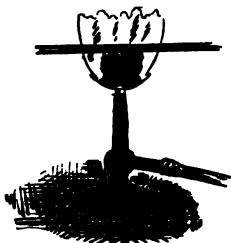


Fig. 5.

If it does not bend easily, heat it again. Bend also one piece of tubing (50^{cm} long), 5 or 6^{cm} from one end. Round the sharp corners of each by holding the tip ends of the tubes in the edge of a Bunsen flame for a minute (Fig. 3). Do not let any part of the heated glass touch any object and avoid wiping off the soot till the glass is cool enough to handle, when it should be cleaned.

IV. Delivery Tubes.

Examine the angles (all obtuse) and the relative lengths of the parts in Fig. 6 and in a model, noting that the bends *a* and *c* are very near the ends, and *a* and *b* are close together. Do this work very carefully. Use a piece of glass tubing 50^{cm} long, holding it as before. Make the bends in the order *a*, *b*, *c*. Hold the glass constantly in the flame, turning it occasionally to heat both sides.

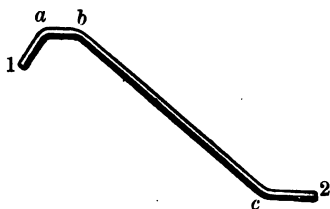


Fig. 6.

When it yields remove and bend it out of the flame. To make the bends at *b* and *c*, turn the glass quickly and — closing one eye — sight along the tube so as to have all parts lie in the same plane. Round the sharp edges 1 and 2 in the flame, as before, and cool with care. Show all results to the instructor.

V. Perforating Corks.

Fit a cork to a t.t., remove it and with a round file bore a hole in it — holding the cork in the left hand and pressing the end of the file against its *larger* surface. Observe constantly during the operation whether the perforation is perpendicular to the surface of the cork. The orifice must be perfectly circular and a little smaller than the tube it is to receive. When completed, adjust to the d.t. and t.t. Detach the stopper from the t.t., not from the d.t.

4. PHYSICAL CHANGES.

Solution.

See whether crystals of granulated sugar, $C_{12}(H_2O)_{11}$, can be crushed. Put into a t.t. 5^g or more of the sugar, just cover it with water, H_2O , and boil in a Bunsen flame for a minute, using a t.t. holder of wood, metal, or paper (Fig. 7), till the sugar dissolves. Cool it by holding the tube under a jet of water, and when cool taste a drop of the liquid. Have the sugar particles been divided by dissolving? How do you know? Arrange a filter paper (Fig. 8) and filter the sol., using a filter stand and collect-



Fig. 7.



Fig. 8.



Fig. 9.

ing the filtrate in another t.t. (Fig. 9). Touch a drop of the filtrate to the tongue with a stirring rod (s.r.). Note whether the sugar has gone through the filter paper.

Divide the liquid into two parts. Save one for Exp. 6, and dilute the other with an equal vol. of H_2O ; then cover the t.t. with the thumb or hand, invert it (Fig. 10) and, *holding it away from the table*, shake the contents vigorously. Taste a drop of the sol. Note whether the sugar particles have been further divided.

Supplementary. — Read very carefully Rule 14 and the Model for Taking

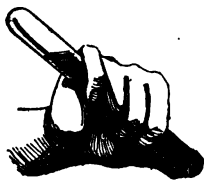


Fig. 10.

Notes. (a) Dis. a little $CuCl_2$ or $Cu(NO_3)_2$ in water, boiling as before, and filter but do not taste the sol. (b) Dis. also a little $NaCl$, filter and taste the filtrate. Evaporate. Do substances in sol. pass through a filter paper? Many substances like SiO_2 and $BaSO_4$ are not sol. in water or acids, others, like Zn , Cu , etc., are sol. in acids only. (c) Heat a platinum wire in a Bunsen flame. Note if it undergoes change.

Terms: Physical division, physical solution, insoluble, dilution, molecule, evaporation, properties, filtrate, residue.

5. PHYSICAL CHANGES.

Solution and Crystallization.

1. Fill an e.d. $\frac{3}{4}$ full of water, heat it, and add small pieces of alum until the liquid becomes thick. Replace the water lost by evaporation. Now put in a narrow piece of cotton cloth so that it lies in the liquid but does not touch the bottom of the dish, and set the latter aside to cool. Observe occasionally, meantime doing the following :

2. Cautiously* boil about 5^g copper sulfate in 5^{cc} H₂O in a t.t. until it is dissolved. Then place the t.t. in an oblique position and let the liquid cool. If necessary, leave till the next laboratory hour. Note the formation of crystals in 1 and 2, and observe their form, color, luster, angles, etc. Are these illustrations of physical or of chemical changes, and why? Trace each step in the process. Which seems more soluble, alum or sulfate of copper? Are they more soluble in hot or in cold water?

3. Put a few crystals of copper sulfate into an i.t. or small t.t. and slowly heat. Observe the sides of the tube and any change of color, luster, hardness, and form in the crystals. Explain. When the tube is cool add a drop of water.

4. Experiment in the same way with some of the crystals of alum, tasting the powder obtained by heating.

5. Put a crystal of sodium sulfate and a small piece of calcium chlorid on separate pieces of paper and leave them in the locker exposed to the air till the next exercise. Describe the result with explanation.

Supplementary. — (a) Put into an e.d. as much powdered S as will stay on the point of a very small knife blade. Cover it with a very little CS₂ (keep the flame at a distance from this substance) so as to dis. the S, let it evaporate in a draft of air, then watch closely as the CS₂ evaporates. Describe and explain the phenomena. Put a drop of this sol. on a microscopic slide and watch it closely under the microscope as the CS₂ evaporates. (b) Dissolve and re-crystallize Na₂SO₄. (c) Mix sols. of alum and CuSO₄ and try to crystallize the two substances together. Are the above salts soluble or insoluble?

Terms: Crystal, amorphous substance, mother liquor, saturation, super-saturation, water of crystallization, deliquescent, efflorescent, luster.



6. CHEMICAL CHANGES.

I. Sulfuric Acid and Sugar.



Fig. 11.

To the sol. saved from Exp. 4 slowly add sulfuric acid, H_2SO_4 , in a small stream, holding the tube with a t.t. holder, and the bottle as in Fig. 11 (read Rule 9), till the substance changes color. Add a little more acid, and if the sugar solution is strong enough it will cause the substance to swell and run over the tube. Observe the color, odor, and temperature, but do not taste it. Does it appear to be a solid or a liquid? Sugar is a compound of C and H_2O . H_2SO_4 has great affinity for water. From these facts explain the phenomena. Clean the tube with water, using a brush if necessary.

II. Heat and Sugar.

See whether heat will break up sugar, by dipping a short piece of glass tubing moistened with water into a little sugar and holding it in a Bunsen flame. Describe all you see, note the odor, and state your conclusions. What produced the chemical change?

III. Combustion of Wood.

Hold a small stick in a flame. State whether the changes observed are chemical, or physical, with reasons.

IV. Changes in Solutions.

Add a little hydrogen chlorid, HCl , to 5^{cc} $\text{Pb}(\text{NO}_3)_2$ sol. The hydrogen chlorid and the lead nitrate have become lead chlorid and hydrogen nitrate. The former product is insoluble and is therefore thrown down (precipitated). To 5^{cc} of CuCl_2 sol. add a little NH_4OH — ammonium hydroxid — and notice any evidence of change.

Supplementary. — (a) To 5^{cc} of HgCl_2 sol. add a few drops of KI sol. (b) Add a few drops of KI sol. to 5^{cc} of $\text{Pb}(\text{NO}_3)_2$ sol. (c) On a few bits of Cu in an e.d. pour a few drops of nitric acid, HNO_3 . Describe all you see. Are these chemical, or physical changes? Why?

Terms: Combustion, chemical solution, affinity, precipitation, chemical change.



7. ELEMENTS AND COMPOUNDS.

Synthesis.

Fill an i.t. (from Exp. 2) not over $\frac{1}{3}$ full of an *intimate mixture* of one part by weight of S (finely powdered brimstone, or flowers of S) with two parts of fine Cu filings. Observe that the two elements are entirely distinct, and note the color and luster of each. Now heat the tube very slowly for a minute (moving it alternately out of the flame and into it, so as not to break the glass) then heat very strongly, the upper part first (Fig. 12). Watch the contents of the tube for evidence of a chemical change. What is the

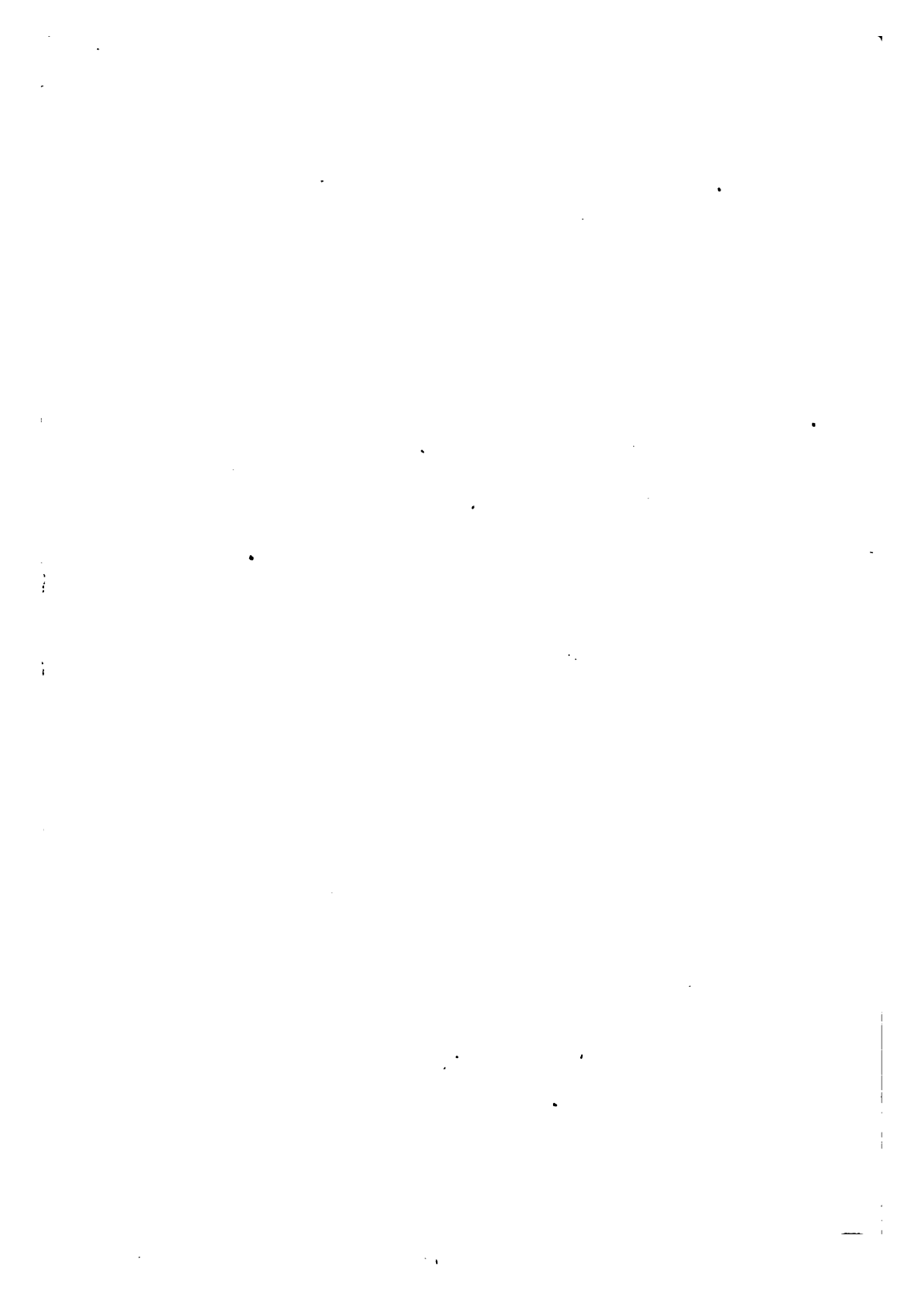


Fig. 12.

evidence? When this change has taken place throughout the whole mass let the tube cool for a minute, then heat an instant, break the tube with a jet of water, and examine the substance. Note whether it resembles Cu or S in color or luster. Describe fully what you saw, state what is supposed to have taken place, and give an equation to express it.

Supplementary. — (a) Mix Fe filings and S (in about the same proportion as Cu and S), try to separate the Fe with a magnet and the S with CS_2 from a part, then heat the other part in an i.t. Test the product with magnet and CS_2 ; also by adding a little H_2O and then HCl in an e.d. An offensive gas is liberated which either element alone would not give if similarly treated. Describe fully with equations. (b) Light a match, and as it burns watch the colors of the flame and see if there is any evidence of a product being formed. The match contains the elements P, S, and C, which combine with the element O in the air to form compounds called oxids of P, S, and C (v. Exp. 9). (c) Burn a piece of charcoal and observe. The products are for the most part invisible gases. (d) Heat in an i.t. a little granular pyrite, FeS_2 , and finally test the residue with a magnet.

Terms: Synthesis, sulfid, oxid, binary compound, element, gas, luster, residue.



OXYGEN.

— with water, invert on the shelf of a p.t. which the water is 3 or 4 in. above the shelf. Mix on a paper 5 or 10^g KClO₃ (finely pulverized) and 3 or 4^g powdered MnO₂. Put the mixture into a large dry test tube which should not be over half full. Adjust a stopper and hang the app. on a retort stand (Fig. 13). Direct a Bunsen burner flame at the mouth of the tube and slowly moving it away from the mouth the tube will melt. Watch the evolution of gas in the recs., and test it, and whether the gas is O₂. At a time observe again. Is it a solid, or both? As the reaction proceeds, remove the d.t. from the stand, drawing back and breaking it. What is this back action? Let the d.t. cool, if wanted, or, if taken from the stand, place it on glass plates (Fig. 14). Rub the residue with a glass rod, or the thumb or hand, and remove it from the table.

Now compare the volume of the gas with the factors of the reaction. Is it high more, or less? Why? How can it be distributed and equalized? Name all the substances

9. COMBUSTION IN OXYGEN.

1. Put a burning splinter into a rec. of O for an instant, note the color and vigor of the flame, then remove, blow out the flame and put in the glowing stick. Repeat till there is no effect. State accurately everything you saw and heard. Wood consists largely of C. Explain the combustion and write an equation for it. Test the product by adding 4 or 5 cc of lime water, $\text{Ca}(\text{OH})_2$ sol.; shake it well and notice the effect.

2. Make a d.s. by hollowing out the end of a crayon, or electric light carbon, and attaching a Cu wire. Put into it a bit of S, hold the whole in a flame till the S burns, then lower it into a rec. of O (Fig. 15). Notice the color and vigor of the flame, and the color and state of the product, explain what you see and write the equation. Name the product and test it by cautiously noting the odor, and also by putting a drop of $\text{K}_2\text{Cr}_2\text{O}_7$ sol. on paper and holding it in the gas, noting any change of color.



Fig. 15.

3. Put into an e.d. with a pair of forceps (don't handle it) a piece of P, half as large as a pea. Dry it by rolling it lightly on paper, then put it into a d.s. Heat for an instant the end of a wire or file, touch the P with it and lower the spoon at once into a rec. of O. Observe the color of the flame and of the product. Describe, also write the equations. When combustion stops burn every bit of the P by holding the d.s. in a flame. Add a few cc of H_2O to the rec., shake it well and drop in a piece of blue litmus paper.

Supplementary. — What became of the O in the above cases? Would the product in each case weigh more or less than the C, S, P? How do you know? (a) Cover the bottom of a rec. of O with sand or H_2O 1 or 2 cm deep. With forceps hold for an instant in a flame one end of a picture-cord wire 5 or 10 cm long, then dip it into a bit of powdered S. Hold it again in the flame till the S burns, then thrust it into the rec. of O. If the Fe does not burn try it again, or repeat with another rec. (have but little S on the wire). Describe the combustion and the product, and give the equation. (b) With forceps hold in the flame a piece of Mg ribbon till it begins to burn, then instantly thrust it into a rec. of O. (c) Try Zn tipped with S.

Terms: Supporter of combustion, combustible, kindling point.

10. OXYGEN.

I. Oxygen from Oxide.

Heat strongly 1 or 2^g of HgO in a t.t. or i.t. and thrust a glowing splinter into the tube while still holding it in the flame (Fig. 16). Note the color of the HgO while it is being heated, observe the sides of the tube, and finally pour out and carefully examine the contents. Explain, and give the reaction. Save the residue.



Fig. 16.

II. Oxygen from Nitrates.

Put into a t.t. about 1^g of $\text{Pb}(\text{NO}_3)_2$, heat it and test the gas as before. Note any snapping, the color of the fumes, which are NO_2 and O (the O being colorless), and the color of the residue, PbO . Also write the equation.

III. Oxygen from Chlorates.

Try to obtain oxygen in the same way by heating a few crystals of KClO_3 . Test as before, and write full notes.

Supplementary. — What 3 classes of substances have you found which yield O ? From which is the oxygen obtained most easily? N_2O will also support combustion of C, S, P, but not as readily as pure O . Heat and test: (a) Pb_3O_4 ; (b) NaN_2O_2 .

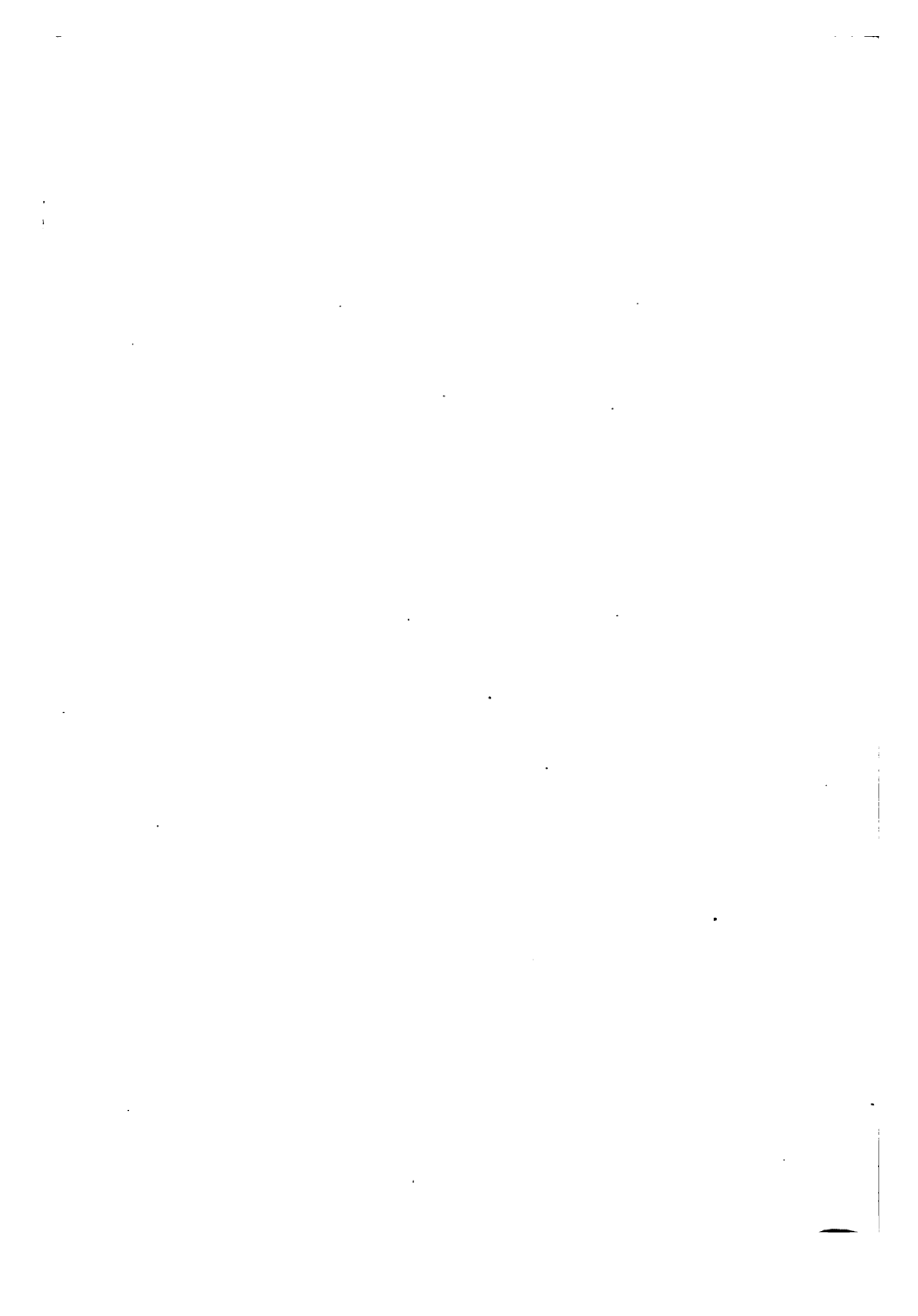
Terms: Oxid, chlorate, chlorid, nitrate, residue.



NITROGEN.

the shelf. Prepare a d.s. sharply 5 or 6^{cm} from the wire through the orifice in the rec. It will reach half way up and set it there (so as to be easily removed from the mouth of the rec. under the glass). When adjusted remove the wire. Using forceps and e.d. put a piece the size of half a pea into the rec. Turn it with a warm (but not too hot) water. Invert the rec. over it as before. Hold it steadily with the hand. Does any escape of gas? Before reaction has stopped, and let no air enter the product with the same in the equation. Finally remove the wire. Turning the rec. Burn any gas that still the gas becomes tolerable, turning the rec. right side up. Set this aside for

in air with S in a d.s., setting the spoon. (b) Try paper or other substance to exist in the air? N may also exist in the air. It may be which forms CuO . It may be ammonia.



12. NITROGEN AND AIR.

I. Properties of N.

(1) Put a burning stick into the rec. of N (Exp. 11), sliding along the glass cover enough to admit it. Note the effect on the stick and on the gas. Try it with a glowing stick. Is the spark rekindled, or extinguished? (2) See whether the P, S, and C on the end of a match will burn in the gas. Is there any equation? Why? Is N a combustible? A supporter of combustion? (3) Test the liquid with blue litmus paper. Describe and explain.

II. Composition of Air.

Measure accurately the water in the rec. of N by pouring it into a graduate and recording the volume in cc. Then measure the total capacity of the rec. in the same way, and *compute the percentage of O and of N* (by volume) in the air, giving the computation and remembering that the first vol. of water represents the vol. of O burned. If any air was forced out in Exp. 11, will the per cent of O found be too large or too small? Explain.

Supplementary. — Compare the properties of N with those of O. Air contains also CO_2 (tested for by Exp. 36) and H_2O (shown by setting a pitcher of cold water in a warm room). Make tests for each and explain. From the percentage of N there must be subtracted about 1% of the recently discovered element argon, A, a gas more inert than N.

Terms: Inert substance, percentage by volume and by weight, acid, litmus paper.

13. HYDROGEN FROM ACIDS.

I. Preparation.

Fill 4 or 5 recs. with water and invert in a p.t., then put into the gen. (Fig. 18) (or use the same app. as for making O) 8 or 10^g granulated Zn, cover with H₂O and add 5^{cc} of HCl through the thistle tube. Have the bearings perfectly tight, and, without applying heat, collect the gas like O. Observe and describe the action and note any heat. If action stops add more HCl. Leave the recs. of gas in the p.t. till wanted in II (or if removed keep them inverted, Fig. 19). Has the gas any color? Why? Clean the app. and save the Zn.

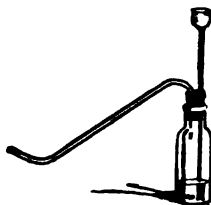


Fig. 18.

II. Tests.

(1) Lift a small rec. of H, hold it inverted, and thrust a burning stick into the gas. Note any explosion and whether the gas or splinter burns. (2) Try it with another rec. and then cautiously look into the open mouth of the latter, noting the colors of flame. Explain fully the explosion, combustion, etc., with equation. Note the (3) color and (4) odor of (the impure) H. (5) Collect by up. disp. a t.t. of H, and test by putting it mouth to mouth with a t.t. of air and then bringing the two open tubes successively to a flame.

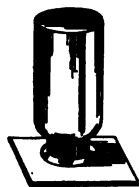


Fig. 19.

Supplementary. — (a) Put 2 or 3 small pieces of Zn into a t.t. (use a t.t. holder), cover it with water and add a little H₂SO₄. Notice the action, test the combustibility of the gas, and write the equations. (b) Put into a t.t. a few Fe filings, add H₂O and HCl. Test the gas as before. (c) Try Fe and H₂SO₄. Make a complete record of all work. From what class of substances has H been obtained, and how? Is H a combustible? A supporter? (d) Try the action of Zn and H₂SO₄, without H₂O, cautiously noting the odor. (e) Pass H into euehlorin (Exp. 38). (f) Fill a rec. half full of water, invert it in a p.t., letting air fill the upper half. Now fill the rest with H from a gen., then bring the mouth of the rec. to a flame. (g) Make a philosopher's lamp (Fig. 20), but before lighting the hydrogen, test the gas by collecting a t.t. full by upward displacement and bringing it to a flame. If a sharp sound ensues there is danger, as the gen. contains air. If only a low muffled sound, the gas may be lighted. Lower a larger open glass tube over the flame. Other flames give the same result.

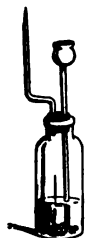


Fig. 20.

Terms: Upward and downward displacement, philosopher's lamp, singing flame.

WATER.

H_2O . Have a cover of
Observe the color and
Take a small piece from
Keep (using forceps and
and cover the latter at
action, note any fumes
Write equations. When
and bring the fumes
the lower openings of
notice the color im-
for Na and its cpds.
What becomes of them?
In the fumes, also put
adding a little to these

boiling a little H_2O in a
a piece of Na on it and
and write equations
combustion of H, and

cold H_2O , and making
flame tests.

for H_2O , Na or K? (a) Col-
and quickly thrust it under
What proportion of H in
heavier or lighter than H_2O ?
drop on the moist paper a
the fumes by bringing a
same with K.

15. AMORPHOUS CARBON.

I. Carbon from Wood.

Put 2 or 3 small, thin pieces of wood into a small Hessian crucible and cover them with sand (Fig. 22). Apply a Bunsen flame for half an hour, or until gases cease to come off (meanwhile do II, III, and Exp. 16). Notice any gases rising and try to kindle them. Observe the color and odor. Finally remove the carbon with forceps and save the sand. Examine the carbon as to color, weight, volume, porosity, and brittleness (compare with the original wood). See whether it burns with flame or only glows, on igniting it in a flame.

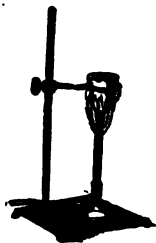


Fig. 22

II. Carbon from Candle, Oil, Gas.

Hold a short piece of white crayon, or of glass tubing, in the flame of a Bunsen burner, with the lower openings closed, then open the orifices and try to burn off the deposit. Try to collect C from a candle flame and from that of a kerosene lamp in the same way. The candle, oil, and gas consist mainly of cpds. of C and H. Which seems to burn at the lower temperature, C or H?

III. Carbon from Sugar, Starch.

Heat in a narrow tube a very little sugar, also starch. State what you see and conclude.

Supplementary. — Gases burn with flame. Solids glow. What has the destructive distillation of wood in I. done? Cpds. of C and H (called hydrocarbons) are solid, liquid, or gaseous. (a) Try to obtain carbon in any other way. (b) Hold a piece of charcoal in water for a minute. (c) Weigh a piece of wood, then distil it, and finally weigh the product. (d) Put some small pieces of wood into an i.t., attach a d.t. and heat. Collect the gas (Fig. 13). (e) Test the gas.

Terms: Amorphous, crystalline, dimorphous, trimorphous, porosity, specific gravity.

16. PROPERTIES OF CHARCOAL.

I. Carbon a Reducing Agent.

Fill an i.t. not over $\frac{1}{4}$ full of an *intimate mixture* of CuO and C (powdered charcoal), about 7 parts CuO to 1 part C by weight. Heat it very cautiously at first, then strongly till you see evidence of a chemical change. What is the evidence? What caused the mixture to rise? After the action stops is there any change in color? When sure that no more action will ensue, cool it for a minute and pour the contents into a dry e.d. Examine it carefully as to color and luster. Explain, giving an equation to express the chemical change.

Finally test the residue by adding 2 or 3^{cc} HNO₃, noting the color of the fumes and of the residue. See whether HNO₃ has a similar effect on the original mixture of CuO and C. What does the test show?

II. Carbon a Decolorizer.

Shake up 5 or 10^{cc} of bone black — animal charcoal — in a t.t. or rec. with 10 or 20^{cc} cochineal sol., then filter and notice the color of the liquid. If not perfectly colorless pour it again on the same filter, using more carbon if needed. Try in the same way sols. of indigo and litmus; also of K₂Cr₂O₇ and KMnO₄. Can you draw any general inference of the decolorizing action on animal, vegetable, and mineral pigments, the first three being animal or vegetable, the last two mineral? K₂Cr₂O₇ may be turned slightly yellow by alkali in the bone black.

III. Carbon a Deodorizer or Disinfectant.

Prepare a sol. of H₂S (Exp. 42). Notice the odor of the gas and its solubility. Put into a rec. 5 or 10^{cc} of powdered charcoal and pour upon it 10 or 20^{cc} H₂S sol. and shake the mixture well. Then pour the whole on a filter, collect the filtrate in a clean t.t. and see if any odor remains; if so, mix and filter again, using more charcoal if necessary. The H₂S has been absorbed physically into the pores of the coal and partially oxidized there. This illustrates the absorbent action of charcoal on gases, animal effluvia, and micro-organisms in the sick room.

17. EXPERIMENTS IN COMBUSTION.

I. Structure of Flame.

(1) Make a careful examination of the parts and colors of a candle flame, and make a drawing to show them. Move the candle slightly in the air to show the outer flame. This is best seen in a dark room. Describe fully. (2) Examine the structure of a Bunsen burner (unscrew the top if necessary), make a drawing to show the orifices, and state what use they subserve. Replace the tube and light the gas. Hold the flame in front of a dark object (as a blackboard), examine the parts, make a drawing, give a brief description, and state the color of each part. If possible, put the flame in direct sunlight, and study the parts from its shadow, to confirm your results.

II. Combustion of Flame.

(1) Put a moist stick across the base of the Bunsen flame for an instant, and notice what parts are burned. Hold a stick just above the inner cone of the flame. Make sketches of results. (2) Press quickly down on the flame with a paper, or pasteboard, remove before it burns, and notice the shape of the charred part, or press down on the flame with a fine wire gauze, and observe by the glowing of the wire where the heat is most intense. Sketch.

(3) Put one end of a small d.t. into the inner blue cone, not into the lamp, and try to light the gas at the other end. (4) Thrust a match quickly into the inner cone near the bottom. If done quickly the phosphorus will not take fire. The match contains a supporter and a combustible. Why does it not burn? In what parts of the flame does combustion occur?

Supplementary. — Examine: (a) an ordinary gas flame; (b) the flame of a kerosene lamp; (c) the flame of a burning splinter, or match, holding it vertical and breaking off the charred part as fast as it forms. Have all flames practically the same structure?

18. EXPERIMENTS IN COMBUSTION.

III. Light of Flame.

(1) Sprinkle a very little charcoal dust into a Bunsen flame, and note any change of light or color, or, better, dip a fine splinter into powdered charcoal and thrust it into the openings at the base. Notice flame. (2) File a nail or other metallic substance over the flame, or sprinkle in CuO , or "iron by hydrogen." (3) Also stir up the dust near the flame, or tap the lamp with the fingers. What produces flame? What is the cause of light in a flame, and what flames give light? (4) Close the orifices at the base of the burner, and explain the change of light. (5) Set fire to a small piece of charcoal, by holding it in a flame, and see whether it burns with flame or only glows. What does this show?

IV. Kindling Point.

(1) Light the gas and hold a fine wire gauze 3 or 4^{cm} above the burner. Why does it not burn above the wire? (2) Extinguish, then relight the gas above the gauze. Result and explanation. Gradually lift the wire till the gas will not burn. (3) Again light the gas above the gauze, and hold another gauze above the flame, so as to confine it above and below. State three conditions of combustion, define each, and show how this exp. illustrates them.

Supplementary. — Why does a lamp smoke? Why does phosphorus take fire spontaneously? Why does gunpowder explode? Why will it burn without air? Why do we exclude the air to put out a fire? Why does blowing a flame sometimes cause it to burn, and sometimes extinguish it? Why does cannel coal burn with flame? When will a mixture of H and air not explode? Why will some substances burn in water? See which has the lower kindling point, P or S, by putting each on one end of a piece of iron at equal distances from a flame which heats the other end.

Terms: Kindling temperature, spontaneous combustion, combustible, supporter.

19. POSITIVE AND NEGATIVE ELEMENTS.

I. Dis. Ag in HNO_3 and ppt. Ag with Cu.

Put a ten-cent silver coin into an e.d. and add 10 or 20 drops of HNO_3 . Warm it, if necessary, over asbestos, and watch the result as to action, color of liquid, color of fumes, etc., and give the reason for each, with equation. When action stops, or the coin is dissolved, add $10^\circ \text{H}_2\text{O}$, then pour it into a t.t. and put in a copper wire (Fig. 23). Leave for 10 to 30 minutes. At this point begin II., but observe any deposit on the wire, noting its color, luster, texture, crystalline form, and any change in the color of the liquid. Explain, giving equation. Save the Ag. Which has greater affinity for NO_3 , H, or Ag? Why is H not set free?



Fig. 23.

II. Dis. Cu in HNO_3 and ppt. Cu with Pb.

Put into a t.t. or e.d. a thin piece of sheet Cu, say 1^{cm} ; add 10 or 20 drops HNO_3 . Make as accurate observations and notes as before, including equation. After dissolving the Cu add $10^\circ \text{H}_2\text{O}$, and put in a Pb wire (or other piece of Pb), made bright with a file or by just dipping it into a little HNO_3 . Leave it for some time in the $\text{Cu}(\text{NO}_3)_2$ sol., and begin III. Afterwards notice the deposit, the color of liquid, etc., as before, and take full notes with equations. Which has more affinity for NO_3 , Cu, or Ag?

III. Dis. Pb in HNO_3 and ppt. Pb. with Zn.

Dis. part of a small piece of Pb in a few drops of HNO_3 , heating if necessary, and when action ceases add $10^\circ \text{H}_2\text{O}$; pour the liquid into a t.t. and put in a piece of Zn. There should be scarcely any free acid when the Zn is introduced, or violent effervescent action will ensue and both Pb and Zn will dissolve. Make full notes as before, including equations.

Supplementary. — (a) Obtain crystals of pure AgNO_3 from a coin. (b) Of $\text{Pb}(\text{NO}_3)_2$ from Pb. (c) Of $\text{Cu}(\text{NO}_3)_2$ from Cu. (d) Make CuSO_4 from Cu with dil. acid. (e) See whether Zn will ppt. Cu from CuSO_4 . (f) From CuCl_2 . With 1° of pure Ag, how much AgNO_3 could be made? How much Ag will 5° of Cu replace from a sol. of AgNO_3 ?

Terms: Chemical solution, physical solution, precipitation, stoichiometry.

20. ACIDS, BASES, SALTS.

I. Acids.

(1) Pour into an e.d. a few drops of HCl , add 4 or 5 $^{\circ}$ H_2O , stir it, taste a drop from the s.r.

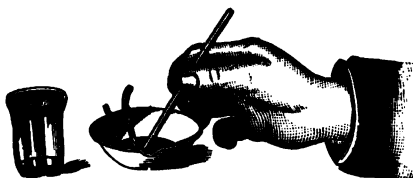


Fig. 24.

(Fig. 24). Dip the end of a strip of blue litmus paper into it. State results. (2) Rinse the e.d., then put in a few drops HNO_3 and 5 $^{\circ}$ H_2O , stir and test as before. (3) Test

in like manner H_2SO_4 . What do these exps. teach you of acids?

II. Bases.

(1) Pour into an e.d. 1 or 2 $^{\circ}$ NH_4OH , add 4 or 5 $^{\circ}$ H_2O , stir it, and taste a drop. If it has no taste add more NH_4OH . Dip the end of a piece of red litmus paper into it. (To redden blue litmus hold it in the *fumes* of HCl . To turn red litmus paper blue hold it in NH_3 *fumes*.) (2) Rinse the e.d. and test NaOH sol. in the same way. Also (3) KOH sol. What do these exps. teach concerning bases?

III. Salts.

(1) Pour into a clean e.d. 1 or 2 $^{\circ}$ of NaCl sol., taste a drop of it, and test it with litmus, red and blue. Test in the same way (2) KNO_3 sol., also (3) a sol. of $(\text{NH}_4)_2\text{SO}_4$. What is the usual action of salts on litmus? Test, however, these sols. with both colors: (4) Na_2CO_3 ; (5) CuSO_4 ; (6) HNaCO_3 ; (7) HNaSO_4 .

Supplementary. — Test sols. of: (a) H_3PO_4 ; (b) $\text{H}_2\text{C}_2\text{O}_4$; (c) $\text{HC}_2\text{H}_3\text{O}_2$; (d) $\text{Ca}(\text{OH})_2$; (e) $\text{Ba}(\text{OH})_2$; (f) HNa_2PO_4 ; (g) $\text{Na}_2\text{B}_4\text{O}_7$; (h) NH_4NO_3 .

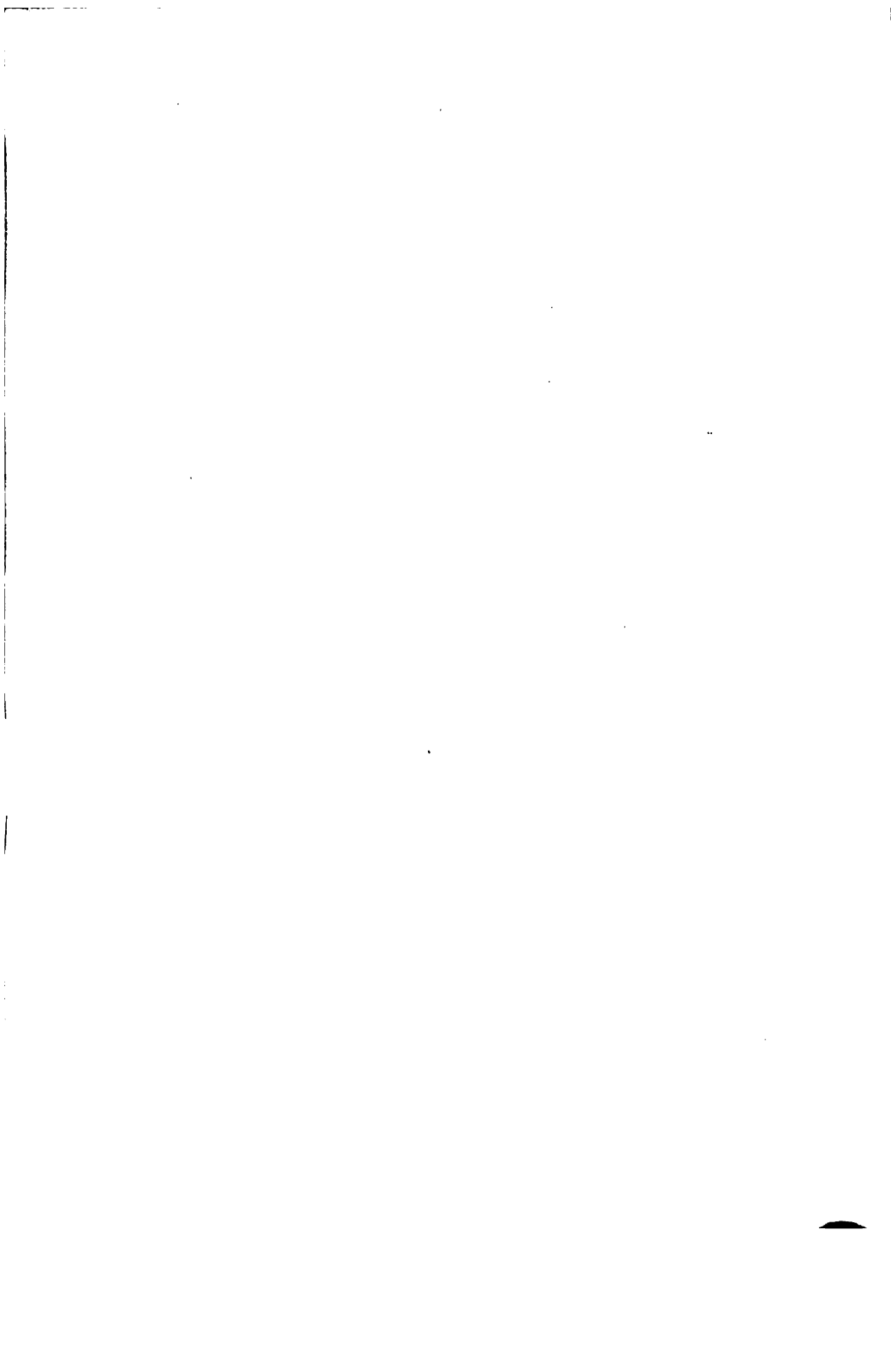
Terms: Acid, base, salt, acid salt, normal salt, alkaline salt, neutral salt, salt acid to litmus, alkali, fixed alkali, volatile alkali, alkaline carbonate.

21. ACID, ALKALINE, AND NEUTRAL REACTIONS.

Put into a small beaker or a t.t. 5^{cc} of an aqueous sol. of blue litmus. (1) Pour a few drops of HCl into an e.d., beaker, or t.t. and dip a s.r. into this (never dip a rod into a reagent bottle), then stir the litmus solution with it, noting any change of color. If none occurs add another drop of acid with the rod. (2) Pour a few drops of NH_4OH into a clean e.d. or t.t., dip the s.r. into it, then stir the litmus solution with this. If the color is unchanged repeat till blue is again obtained. (3) In the same way put a drop (or more, if necessary) of HNO_3 from an e.d. into the same blue solution. (4) When it is reddened add a drop or more of NaOH sol. until it becomes blue. (5) Change it again to red with a drop of H_2SO_4 , and (6) restore the color with KOH sol.

Supplementary. — (a) Add a few drops of H_2O to a sol. of red litmus, and also to one of blue. (b) Add to both red and blue litmus sols. a sol. of NaCl. (c) Try NH_4Cl sol. (d) KNO_3 sol. (e) HNaCO_3 sol. (f) HKSO_4 . (g) CuSO_4 .

Terms: Acid, alkaline, and neutral reactions.



22. SOLUBLE SALTS BY NEUTRALIZATION.

I. Sodium Chlorid.

Pour into an e.d. not over 5^{cc} NaOH sol., and into a clean t.t. or



Fig. 25.

beaker 4 or 5^{cc} HCl. Now add some of this latter, a little at a time (Fig. 25), to the NaOH sol., stirring it meantime till the product is neutral to litmus paper; when nearly neutral add a drop at a time with a

s.r. and test with both colors, using only the end of the paper and keeping it on the side of the e.d. If blue litmus paper is reddened by the sol., add NaOH sol., a few drops at a time. If red litmus is turned blue add a drop of HCl. When the sol. does not affect either red or blue litmus left in it for a minute, show it with both papers in it. to the instructor, then filter and evaporate the liquid to dryness by boiling it over a plate and abestos paper (Fig. 26). When it is cool, examine the residue and taste it. What is the object of evaporation? Explain what took place when the acid and base were mixed, and give the equation to express it. Sift a little of the salt into the flame. The color shows a cpd. of Na. Test for Cl by Exp. 27.



Fig. 26.

II. Potassium Sulfate.

Into an e.d. put 5^{cc} KOH sol. and neutralize it with dilute H₂SO₄, using both test papers. When sure it is neutral, evaporate most of the water and taste the product. Explain the action, giving the equation. Sift a little into a flame. The color shows a K cpd. (best seen through blue glass). Test SO₄ by Exp. 31.

III. Ammonium Nitrate.

Neutralize NH₄OH with HNO₃ (preferably dilute) in the same way as before. Stop evaporation when dense fumes begin to appear. These fumes indicate a decomposition of the salt by heat (v. Exp. 34).

Supplementary. — How would you make by neutralization NaNO₃, Na₂SO₄, KNO₃, KCl, NH₄Cl, (NH₄)₂SO₄? Write also equation for each. Weak acids will not neutralize strong bases, and *vice versa*. Hence, salts like Na₂CO₃ are not neutral. How do these exps. illustrate the law of definite proportion?

Terms: Neutralization, double decomposition, definite proportion, evaporation, fumes.

23. SOLUBLE SALTS FROM METALS.

I. Zinc Chlorid.

To a piece of Zn in a t.t. add water and a little HCl. Describe and explain the action, and when it ceases, pour the liquid into an e.d. and evaporate to dryness. Observe and taste the salt. Name it and write the equation. To test the salt, add a little H_2O to dissolve it and divide the sol. into 4 parts. Test for Cl by Exp. 27, and for Zn by Exp. 70.

II. Iron Sulfate.

Dissolve as above a few Fe filings in dil. H_2SO_4 . When action stops add H_2O , filter, and evaporate the filtrate. Then dissolve the salt in water after having examined it. Name it and write the equation. Test it for Fe by Exp. 63, and for SO_4 by Exp. 31.

III. Copper Nitrate.

Dissolve a little Cu in dil. HNO_3 , pour off the liquid, evaporate, and then add H_2O . Test for Cu by Exp. 56, and for NO_3 by 82. Make full notes.

Supplementary. — The salts in Exps. 22, 23 are sol. in water. Insoluble salts are not made in this way. $PbCl_2$ is only partially insoluble, hence HCl will not dissolve much Pb. Table A shows that there are but two soluble salts of Pb; hence most acids do not act upon that metal. By reference to this table you can judge what acids will probably act on a given metal. Will H_2SO_4 dis. Ba? Pb? Cu? Will HCl probably dis. Sn? Ag? Hg? Mg? Will H_3PO_4 dis. Pb? Ca? Ag? (a) Try any of the above. (b) Try to dis. Pb in $HClH_2O_2$. Compare chemical sol., as shown in 23, with physical sol., Exp. 4. What two processes in chemical sol.?

Terms: Insoluble, soluble, saturation, supersaturation.

24. SOLUBLE SALTS FROM CARBONATES, HYDROXIDS, OXIDS.

I. Carbonates.

(1) To a piece of CaCO_3 (marble or limestone) in a t.t. add H_2O , and a little HCl . When the action stops, pour a little of the liquid into an e.d., evaporate and notice the residue. See if it will dis. in H_2O . State your observations and the reaction. Test for the presence of Ca by Exp. 74. (2) Try Na_2CO_3 (or HNaCO_3) with HCl . (3) CaCO_3 may be tried with H_2SO_4 or HNO_3 .

II. Hydroxids.

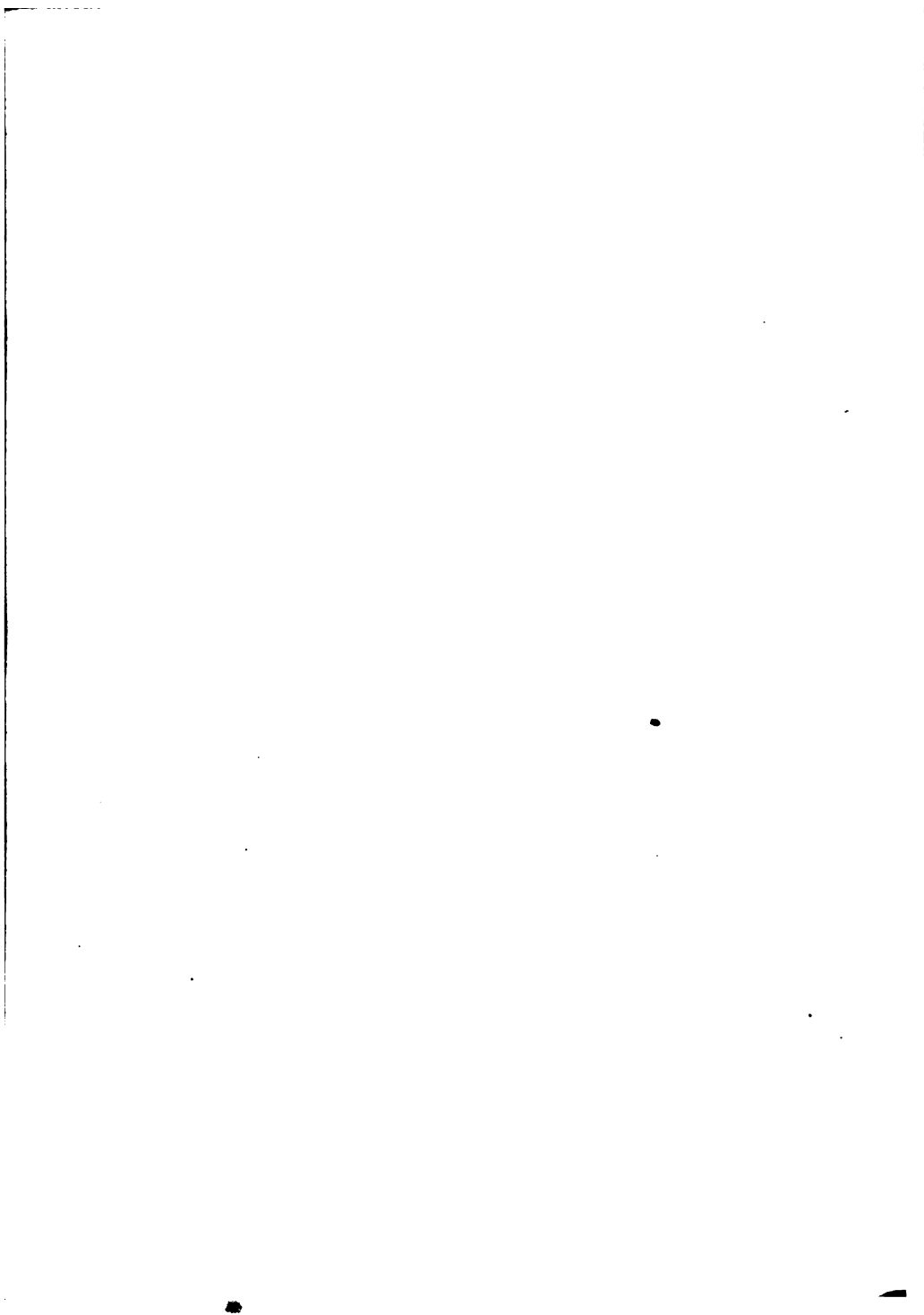
(1) To some $\text{Fe}(\text{OH})_3$ (made by adding NH_4OH to FeCl_3 sol., and pouring off the supernatant liquid after the ppt. settles) add drop by drop just enough HCl to dissolve it. (2) Try also HNO_3 and H_2SO_4 on separate ppts. of $\text{Fe}(\text{OH})_3$. Evaporate and dis. in H_2O as before. Test for Fe by Exp. 63. (3) Try $\text{Al}(\text{OH})_3$ (made from AlCl_3 sol. and NH_4OH) with HCl . Evaporate, dis. in H_2O , and test for Al by Exp. 64.

III. Oxids.

To 2^g PbO (litharge) in an e.d. add some dil. HNO_3 and heat it. Decant on a filter, partly evap. the filtrate, add H_2O , and test for Pb by Exp. 48.

Supplementary. — Notice from Table A what carbonates and hydroxids are soluble. (a) Add H_2O to a little Na_2CO_3 (or K_2CO_3) in a t.t. and boil a minute. (b) In another tube cautiously add HCl to Na_2CO_3 . Explain the difference between (a) and (b). (c) Into (a) pour cautiously a little HCl . Describe the action and explain it with reaction. Sol. salts may be made from many other classes of cpds. besides the above.

Terms: Physical and chemical solution, decantation.



25. INSOLUBLE SALTS BY PRECIPITATION.

Insol. Salts of Pb.

(1) Pour into a t.t. 5^{cc} $\text{Pb}(\text{NO}_3)_2$ sol. and add a few drops HCl . (2) Try it again, substituting NaCl sol. for HCl . (3) Use also a sol. of NH_4Cl . Record results and write equations. (4) Now in place of $\text{Pb}(\text{NO}_3)_2$ use a sol. of $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$, try the action of the same three reagents as previously used, and make a similar record. What is the ppt. in each case? Could you obtain the same ppt. by putting together any other sols., and if so, what ones?

To 5^{cc} of each of the following sols. in a t.t. add a little sol. of $\text{Pb}(\text{NO}_3)_2$ or $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ and write the equation, underlining the ppt. and writing the color above. (5) K_2CrO_4 . (6) KI . (7) KBr . (8) NaOH . (9) Na_2CO_3 . (10) Na_2SO_4 . (11) K_4FeCy_6 .

Supplementary. — What are the only two soluble salts of Pb? Law of Ppn.: *Whenever a mixture is made of two sols., one of which contains the positive part and the other the negative part of an insoluble cpd., a ppt. of the insol. cpd. will always form.*

From Table A what salts of Ba are insol.? (a) Try to make some of them by the application of the above law. (b) Also try $\text{Fe}(\text{OH})_3$. (c) Make HgS . (d) Try to make MnS . (e) Make CaCO_3 .

Terms: Insoluble, precipitation, positive, negative.

26. HYDROCHLORIC ACID, HCl

Preparation.

(1) Fill 2 recs. $\frac{1}{2}$ full of water. Connect the apparatus as in Fig.

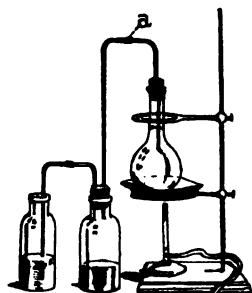


Fig. 27.

27, observing how the tubes extend. (A safety-tube may also be used if desired.) Then put into a flask 10^g NaCl (preferably fused) and 20^{cc} H₂SO₄ which has previously been mixed with 5^{cc} of H₂O. Be sure you have enough acid, or the flask is liable to crack. Heat slowly for 10 or 15 minutes over asbestos, but *do not let the froth extend to the neck of the flask*. Look for any current in the liquid of the rec. and explain. (2) Detach the apparatus

(at *a*, Fig. 27) and pass some of the escap-

ing gas over a few drops of NH₄OH in an e.d. (If much gas is accidentally breathed, inhale NH₃.) Describe the fumes (note whether they have any odor different from HCl or NH₃), name them, state the color, and write the equation for their production. This is the ammonia test for HCl. Ascertain whether the product is gaseous, or solid, by dipping a rod into strong HCl and holding it over a bottle of NH₄OH. (3) Pass some of the gas from the gen. into a sol. of blue litmus. What does this show as to the solubility of HCl? What else does it show?

Supplementary. — How would you test for the presence of NH₃? Generate HCl if possible from: (a) KCl; (b) NH₄Cl, using an open t.t. and applying the usual tests. (c) Try PbCl₂. Law of Formation of Gases: *When two substances, which can react so as to liberate a gas, are put together, that reaction will always take place and the gas be formed.*

Terms: Wolff bottle, flask, safety-tube, muriatic acid.

27. HYDROCHLORIC ACID, HCl.

Properties and Tests.

(1) Test the liquid in each bottle (Exp. 26) with blue litmus paper. (2) Taste a drop, using a s.r. (3) Cautiously note the odor. (4) Put a piece of Zn into a t.t. and pour over it 5 or 10^{cc} of the contents of the first Wolff bottle. (5) If a gas escapes, test its combustibility. Explain fully with observations and equations. (6) Put into a t.t. 5^{cc} $\text{Pb}(\text{NO}_3)_2$ sol. and add a little of the liquid from the first bottle. If a ppt. falls, pour a small part of it into another t.t., add a little H_2O , and boil a minute. Does it dissolve? What does that show? Now add a little $\text{K}_2\text{Cr}_2\text{O}_7$ (or K_2CrO_4) sol. Explain. (7) To 5^{cc} AgNO_3 sol. add a little of the acid. If a ppt. falls let it settle, then pour off most of the supernatant liquid, leaving the residue; then add NH_4OH and shake it. Finally acidify cautiously with HNO_3 . Explain all results. (8) Test HgNO_3 sol. in the same way, adding NH_4OH at the end, but not HNO_3 . By any of the above exps. can you determine which bottle contains the stronger acid?

Supplementary. — (a) Add HCl to $\text{Cu}(\text{NO}_3)_2$ sol. and explain the result. (b) Separate Ag from Cu in a mixture of solutions of their nitrates. Try the action of HCl on sols. of: (c) $\text{Co}(\text{NO}_3)_2$; (d) NaNO_3 ; (e) KNO_3 ; (f) MgSO_4 . What 3 chlorids are insol. in H_2O , and how are they made?

Terms: Analysis, reagent, pungent, acidify, alkalize.

28. ETCHING WITH HYDROFLUORIC ACID, HF.

Cover thinly with beeswax or paraffin one side of a small piece of glass. Spread the wax evenly over the surface, by warming the other side of the glass and pouring off the excess of melted wax. With a sharp metallic point, as the handle of a file, mark some design through the wax when cold (Fig.



Fig. 28.

28). Put into a lead dish (it will spoil a porcelain e.d.) a very little HF sol. (be exceedingly careful not to get any on the flesh) and with a camel's-hair brush spread some of it over the design on the glass. Do this several times. Finally, after a few minutes wash away the acid from the glass, melt and pour off the wax, wiping off what remains with a cloth wet in naphtha, or alcohol. Examine closely the result and describe it. By reason of its affinity for SiO_2 , HF acts on the glass and forms SiF_4 . The equation should be written.

Supplementary. — Etch a t.t. so as to make a graduate of it. Why cannot HF sol. be kept in glass bottles? HF is made by treating powdered CaF_2 (fluorite) with H_2SO_4 in a lead dish. Write the equation (v. Exp. 89 for other tests). The fumes must not be inhaled.

Terms: Etching, fluor spar, fluorid, fluorite, silica.

29. NITRIC ACID, HNO_3 .

I. Preparation.

Introduce into a glass retort through the tubulure, *holding the former so as not to have the chemicals touch the neck of the retort* (Fig. 29), 10 or 15^g fine NaNO_3 (or KNO_3) and 20 or 25^{cc} H_2SO_4 .

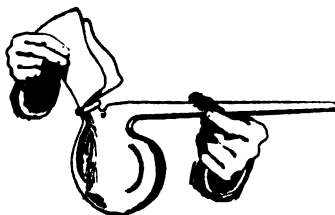


Fig. 29.

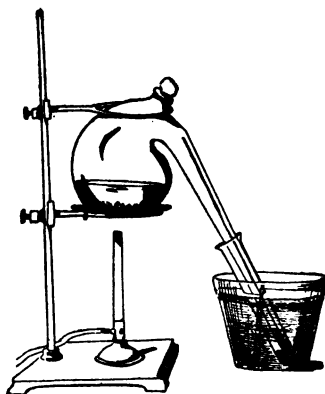


Fig. 30.

Adjust the apparatus as in Fig. 30, having the neck of the retort pass to the bottom of a wide t.t., which is surrounded by water in a wide tumbler, or bottle. The water is to cool and condense the acid from the vaporous state in which it passes over. Apply the Bunsen flame, using a plate and asbestos, for 15 or 20 minutes. Notice the liquid running down the neck of the retort, also any colored fumes — name and account for the latter, and see whether they increase with the heat — the color of the liquid in the t.t., and the cause of it. Do the ordinary reactions (which should be written) account for the fumes? Observe also the color of the product in the retort. Heat may have reduced some of the white Na_2SO_4 to dark-colored Na_2S . Use great care not to get any of the acid on the hands. The anti-

dote, after thorough washing, is HNaCO_3 (v. Rule 19).

II. Tests.

(1) Test the vapor from the end of the retort with a few drops of NH_4OH . (2) Put a drop or more of the acid on a *very few* Cu filings in an e.d. Observe and explain with equation. (3) Try with a s.r. the action of a drop on the finger-nail, then wash it off and add a drop of NH_4OH . This shows its action on animal matter. (4) Try it also on a feather or on silk. (5) Try its decolorizing action on 3 or 4^{cc} of indigo sol. in a t.t. Try its action on insoluble salts, e.g.: (6) CuS ; (7) CaCO_3 ; (8) BiOCl . State what this shows of the solubility of the respective nitrates (v. also Exp. 82).

Supplementary. — (a) Compare the action of HNO_3 and H_2SO_4 on wood. Could HNO_3 be made from $\text{Pb}(\text{NO}_3)_2$? How are nitrates made? (b) Make $\text{Zn}(\text{NO}_3)_2$. (c) Try to dis. a little Sn in HNO_3 in an e.d. (d) Try Sb. (e) Put a drop of commercial HNO_3 on writing paper, another on newspaper. The latter contains wood pulp. (f) Try to decolorize anilin solutions.

Terms: Fuming nitric acid, metastannic acid, xanthoproteic acid, salt of nitric acid, nitrate, tubulure.

30. AQUA REGIA.

I. Preparation.

Pour 2 or 3^{cc} of HNO_3 into a t.t. containing 6 or 8^{cc} of HCl . If there is no evidence of chemical action, warm the mixture a minute and observe. To what is the color due? Give reaction.

II. Tests.

(1) Into a part of the aqua regia introduce a little gold leaf by winding it around a moist s.r., not letting it touch the sides of the t.t. (2) Into another part drop a bit of Pt foil, $\frac{1}{4}$ ^{cm}. If no action ensues, heat it. Pt does not dis. as readily as Au. Try the solvent action of aqua regia on: (3) Zn; (4) Fe; (5) Cu; (6) Pb. Give the usual explanations, reactions, etc., for each of the above exps. Why should not the acid act as well on Pb as on the others?

Supplementary. — See if Au will dis. in: (a) HCl , or (b) HNO_3 . Also try (c) Pt. Try Hg in (d) HCl , then in (e) aqua regia. (f) Try Fe in each and notice the color of each liquid after filtering. Explain. (g) Test the 2 chlorids of Fe by Exp. 63.

Terms: Nitro-hydrochloric acid, gold chlorid, ferrous and ferric chlorids.

31. SULFURIC ACID, H_2SO_4 .

I. Preparation.

Burn a small piece of S in a rec. in which there is H_2O enough to cover the bottom, using a d.s. and confining the fumes as much as possible by covering the mouth of the rec.

Pour into an e.d. 1 or 2^{cc} HNO_3 , and dip into this a piece of strong paper, or cloth, or a wood shaving, and lower it into the rec. of SO_2 , holding it there for some time without dropping any acid from it into the rec. See whether the fumes change color. Repeat the operation several times. Explain the phenomena and give all reactions. Cover the rec. with the hand and shake the liquid and the gases well together.

II. Tests.

(1) Apply the litmus test. (2) Put a drop of the liquid on writing paper, and evaporate it so as not to burn the paper. See whether the paper is charred, blackened, or made rotten by the liquid. Explain. This is a test for free H_2SO_4 . (3) Add a little of the liquid to 5 or 10^{cc} BaCl_2 sol. (or $\text{Ba}(\text{NO}_3)_2$) in a t.t., state the effect and give an equation. If you obtain a ppt., add a little HCl and shake it well. Does it dissolve? (4) Pour into a t.t. containing 5^{cc} H_2O the same amount of H_2SO_4 from the shelf bottles. Observe any thermal effects on this mixture and explain. Save the dilute acid in a separate rec. (5) Apply tests (2) and (3) above to this mixture. (6) Pour a *few drops* of concentrated acid upon 1 or 2^g sugar in an e.d. (7) Dip a small stick into a t.t. which contains 1 or 2^{cc} H_2SO_4 . (8) Pulverize a bit of starch, add a few drops of the acid. If no change occurs, cautiously heat it for a minute. Sugar is $\text{C}_{12}(\text{H}_2\text{O})_{11}$; starch is $\text{C}_6(\text{H}_2\text{O})_5$; cellulose is $\text{C}_{18}(\text{H}_2\text{O})_{15}$; explain the action of the acid.

Supplementary. — Why is commercial H_2SO_4 liable to be of a brown color?

(a) Measure accurately 10^{cc} of concentrated acid in a graduate, leave it in an open t.t. or rec. for a week, then measure it carefully again. Explain the result. (b) Test commercial acid for PbSO_4 by pouring a little into an equal vol. of H_2O in a t.t. BaSO_4 is the only salt of Ba that is not dis. by HCl . (c) Test Na_2SO_4 sol. with BaCl_2 . Explain. (d) Test a sol. of Na_2SO_3 for Na_2SO_4 .

Terms: Salt of sulfuric acid, fuming sulfuric acid, sulfate, starch, cellulose.

32. AMMONIUM HYDROXID, NH_4OH ; AMMONIA, NH_3 .

I. Preparation.

Powder and put into a flask about 10^g NH_4Cl and 7^g $\text{Ca}(\text{OH})_2$ (freshly slaked is best). Add 20^{cc} H_2O and connect with Wolff bottles containing H_2O (Fig. 31), as in the HCl exp. Heat 10 or 15 minutes, using a plate and asbestos paper. Observe the phenomena, especially the pressure in the different bottles and the absorption of gas, and write the reaction. While the mixture is heating, do III.

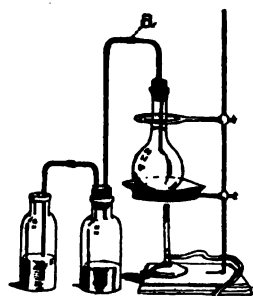


Fig. 31.

II. Tests.

(1) Disconnect the flask while the gas is escaping (*a*, Fig. 31), put 2 or 3 drops HCl into an e.d., and pass the gas over it from the gen. Observe the fumes, giving equation. (2) Let the flask cool as it stands, and test the liquid in each bottle (odor and litmus). Put sol. (5^{cc} each) of the following substances into separate tubes, and add a little of the prepared liquid to each: (3) FeSO_4 ; (4) FeCl_3 ; (5) AlCl_3 . Observe colors, especially of ferrous and ferric cpds. (6) Test likewise CuCl_2 sol., first with very little NH_4OH , then with excess. State and explain all phenomena.

III. Ammonia.

Mix 2 or 3^g of fine NH_4NO_3 with an equal quantity of $\text{Ca}(\text{OH})_2$, put them into a t.t., and warm it over a flame. See whether a gas escapes by: (1) cautiously taking the odor; (2) testing with red litmus paper; (3) with HCl .

Supplementary. — (a) Put into a t.t. a gram or two of either $(\text{NH}_4)_2\text{SO}_4$, NH_4NO_3 , NH_4Cl , or $(\text{NH}_4)_2\text{C}_2\text{O}_4$, and add a little NaOH (or KOH) sol., warm it, and apply tests. What two classes of cpds. are used to obtain ammonia? Are the above examples of double decomposition, and why? Relation between ammonia and ammonium hydroxid? (b) Fill a t.t. with NH_3 by upward displacement, and invert it over a rec. of water. Observe and explain.

Terms: Volatile alkali, fixed alkali.



33. FIXED ALKALIES.

I. Sodium Hydroxid, NaOH.

To 5^{cc} of a saturated sol. of Na_2CO_3 add about an equal quantity of $\text{Ca}(\text{OH})_2$ sol. Shake the mixture well and observe. If a ppt. falls, name it and write the equation. What goes into solution? Let the ppt. settle, then add some of the supernatant liquid to sols. of : (a) $\text{Fe}(\text{SO}_4)$; (b) FeCl_3 ; (c) AlCl_3 . Effects, colors, and equations should be given in each case. If any effect different from what is expected occurs, it should be noted and explained.

II. Potassium Hydroxid, KOH.

Treat a sat. sol. of K_2CO_3 in precisely the same way as Na_2CO_3 above, making close observations and taking full notes as before, including all the tests given.

Supplementary. — Compare the action of fixed alkalies with that of NH_4OH on sols. of Fe and Al salts. (a) Obtain some NaOH or KOH in the solid state. In what other ways were NaOH and KOH made in the laboratory? (b) Would $\text{Ca}(\text{OH})_2$ act on NaCl to form NaOH? (c) $\text{Ca}(\text{OH})_2$ on Na_2SO_4 ? (d) Is FeCl_3 sol. acid, alkaline, or neutral? (e) Is $\text{Al}(\text{OH})_3$ soluble in excess of NaOH or KOH sol.?

Terms: Hydroxid, hydrate, alkali metals, metals of alkaline earths.

GEN.

10g of NH_4NO_3 , not too crystalline (so as not to break the flask in melting). Heat the flask with a large flame, dipping in a rec. of H_2O , or with a rec. *which has no water* (Fig. 33), and heat t.t. or rec. have a d.t. heated to a p.t., so as to collect gas over water. Have the flask light and the tubes pass through the stoppers. Apply heat too rapidly, notice the changes and give the reaction. Are there any changes in the flask? Is the gas colorless and why? Obtain 2 g. of gas, then remove the flask and take the d.t. from the water, setting the flask cool on a wire. (2) Taste a drop of the gas in the large t.t. or rec., and note the odor. Some NH_4NO_3 will give NO , NO_2 , HNO_3 , etc., when heated. Test the gas with a burning splint. (3) Test the combustibility of S and P. Compare the brilliancy of the flames with those in O, and write

Draw an equation for the reaction of NH_4NO_3 with that on $\text{NaNO}_3 + \text{H}_2\text{SO}_4$ (Exp. 29). Name the products of the reaction of N. Try the action of heat on (a) KNO_3 ; (b) $\text{Ca(NO}_3)_2$; (c) $\text{Zn(NO}_3)_2$; (d) $\text{Pb(NO}_3)_2$.

State the action of heat on nitrites.

35. OXIDS OF NITROGEN.

II. Nitrogen Dioxid NO or N_2O_3 (nitric oxid).

(1) Arrange the app., with inverted recs., as for the hydrogen exp. Then put into the gen. (or t.t.) 5^g Cu turnings, cover them with water and add through the thistle tube 5^{cc} of HNO_3 . Collect 2 or 3 recs. of the gas. If action stops add a little HNO_3 (or Cu, if necessary). Save any Cu that is left. Explain the different colors of the gases and the color of the liquid. (2) Test the gas with a burning stick. Explain the fumes. Test also with (3) S and (4) P (well burning). In (4) see whether the solid gradually separates from the gas. Take full notes.

III. Nitrogen Trioxid N_2O_3 and Tetroxid NO_2 or N_2O_4 (peroxid).

(1) Lift a rec. of the gas NO , just prepared, from the shelf of the p.t. What is the effect, what is the new gas, and how is it formed? (2) Heat 1 or 2 crystals of $\text{Pb}(\text{NO}_3)_2$ in a t.t., and while the gas escapes insert a glowing stick into the tube. (3) Put a fragment of starch into a t.t. and add a few drops of HNO_3 . Heat cautiously.

Supplementary. — State how the oxids of N are derived from HNO_3 and nitrates. What action have heat and reducing agents on nitrates? (a) Notice the action of direct sunlight on strong HNO_3 in stoppered bottles. (b) Try the action of heat on other nitrates, e.g., $\text{Cu}(\text{NO}_3)_2$, KNO_3 . (c) Heat a bit of powdered charcoal on a plate or asbestos, and when it is hot add a drop of HNO_3 with a s.r. N_2O_3 and NO_2 are both red and not distinguishable. Find how N_2O_5 is prepared, and its relation to HNO_3 .

Terms: Nitrous and nitric anhydrids, nitrogen peroxid, nitric oxid.



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37. CHLORIN.

I. Preparation from Hydrochloric Acid.

Put into a flask (or t.t.) 5s MnO_2 (preferably granulated) and 10cc HCl . Shake them well together, apply gentle heat, and avoid inhaling the gas, but collect it by downward displacement in a rec. loosely covered with paper. Add more HCl if it is needed. Observe and describe, with equations. Note when the rec. is filled, to avoid passing the gas into the room. If accidentally any is inhaled, the antidote is vapor of alcohol (inhale from a handkerchief); or NH_3 will do. State the color of the gas, its sp. gr. compared with air, its effect on the nasal organs.

II. Tests and Properties.

(1) Drop into the rec. a piece of dry Turkey-red cloth (or of calico), also bits of printed and written paper. If there is little or no effect add a very little water, shake the gas, water, cloth and paper well together, and note the effect. Which bleach better, wet or dry fabrics? (2) Into another rec. of Cl (dried if possible) file a little Sb (or stibnite, Sb_2S_3). Describe the result and give an equation. Is this a case of ordinary combustion? Pass some Cl from the gen. into sols. of: (3) AgNO_3 ; (4) $\text{Pb}(\text{NO}_3)_2$; (5) H_2S .

Supplementary. — (a) Put into a small beaker 5s bleaching powder, CaCl_2O , set this into a larger rec. or beaker, putting into this last the substance to be bleached. Cover the large rec. with pasteboard, through which passes a thistle-tube into the smaller. Pour through the thistle-tube 5cc dilute H_2SO_4 (half H_2O and half acid). Add more, if needed. (b) Mix a gram of fine NaCl with a gram of MnO_2 , add in a t.t. 2cc H_2O and 3cc H_2SO_4 , and heat. Observe any gas. Test it with NH_3 , or otherwise. (c) Dip some unglazed paper into oil of turpentine, $\text{C}_{10}\text{H}_{16}$, in an e.d.; warm it by holding the paper near a flame for an instant (or heat the turpentine in an e.d. over a waterbath), but do not set it on fire. Then at once thrust the paper into a rec. of Cl . Explain the combustion and describe all you saw, giving the equation. Clean the rec. with naphtha or petroleum.

Terms: Bleaching, bleaching powder, calcium hypochlorite, chlorid of lime.

38. EUCHLORIN, ClO_2 , Cl .

I. Preparation.

Drop into a t.t. 3 or 4 crystals of KClO_3 . Add a *few drops* HCl , heat for an instant and then add 5 or 10 $^\circ$ H_2O .

II. Tests.

(1) Observe carefully the action, noting the color and odor (cautiously), and give equation. (2) To 2 $^\circ$ indigo sol. in a t.t. add a little euchlorin. Is the color discharged? Test in the same way sols. of (3) litmus and of (4) cochineal. (5) Try $\text{K}_2\text{Cr}_2\text{O}_7$ sol. (a mineral pigment; the other three are vegetable or animal coloring matters). What do you conclude from this? (6) Very cautiously add 2 or 3 drops of H_2SO_4 to 2 or 3 small crystals of KClO_3 in a t.t. at arm's length from the operator, then fill the t.t. with H_2O . Describe the result with equation. (7) Try to bleach a piece of Turkey-red cloth or calico by putting it into some euchlorin and leaving it a few minutes.

Supplementary. — (a) Try to bleach KMnO_4 sol. Will euchlorin dis.: (b) Au ? (c) Zn ? (d) Cu ? Try its action on sols. of: (e) AgNO_3 ; (f) $\text{Pb}(\text{NO}_3)_2$; (g) HgNO_3 .

Terms: Euchlorin, oxids of chlorin, detonation.

39. BROMIN AND BROMIDS.

I. Preparation of Br.

(1) Make some starch paste by pulverizing a piece of starch not larger than a pea, adding 10^{cc} H₂O and boiling several minutes in a t.t.; cool it and dil. with 10^{cc} H₂O, shaking it well. Boil again if necessary. [Save part of this for subsequent exps.] (2) Mix 1 or 2 crystals of KBr with an equal quantity of MnO₂, put them into a t.t. and add a few drops H₂SO₄. Heat the mixture and observe carefully. Write the equation, and explain the action.

II. Tests.

(1) Dip a strip of paper into the starch paste, wind it around the end of a s.r. and carefully put it into the t.t., so as not to touch the sides. Then heat the mixture in the t.t. Observe the effect of the Br on the starch. The product is supposed to be starch bromid. Avoid getting much Br into the air in the room, or inhaling it. Alcohol vapor, or ammonia, is the antidote, as for Cl. Do you notice any effect of Br vapor on the eyes? (2) To a sol. of KBr add a few drops of euchlorin. Describe and explain, stating which is the more stable or stronger cpd., KBr or KCl, and how this exp. shows it. (3) Add to a few drops of starch paste 10^{cc} H₂O, shake it well, add a few drops of KBr sol. and one drop of euchlorin. Describe and explain.

Supplementary. — Liquid Br should be examined. (a) Try the action of Br on a mixture of starch paste and KI sol. Try the action of H₂SO₄ on (b) a few drops of KBr sol., also on (c) a crystal of KBr. (d) Pour a little Br vapor from a gen. into 5^{cc} of KI sol. (e) Put a drop of CS₂ into a t.t. with a few drops of KBr sol., then add a few drops of euchlorin and shake it. Notice the color of the CS₂ at the bottom of the tube. The Br was set free and dis. by the CS₂.



40. IODIN AND IODIDS.

I. Preparation of I.

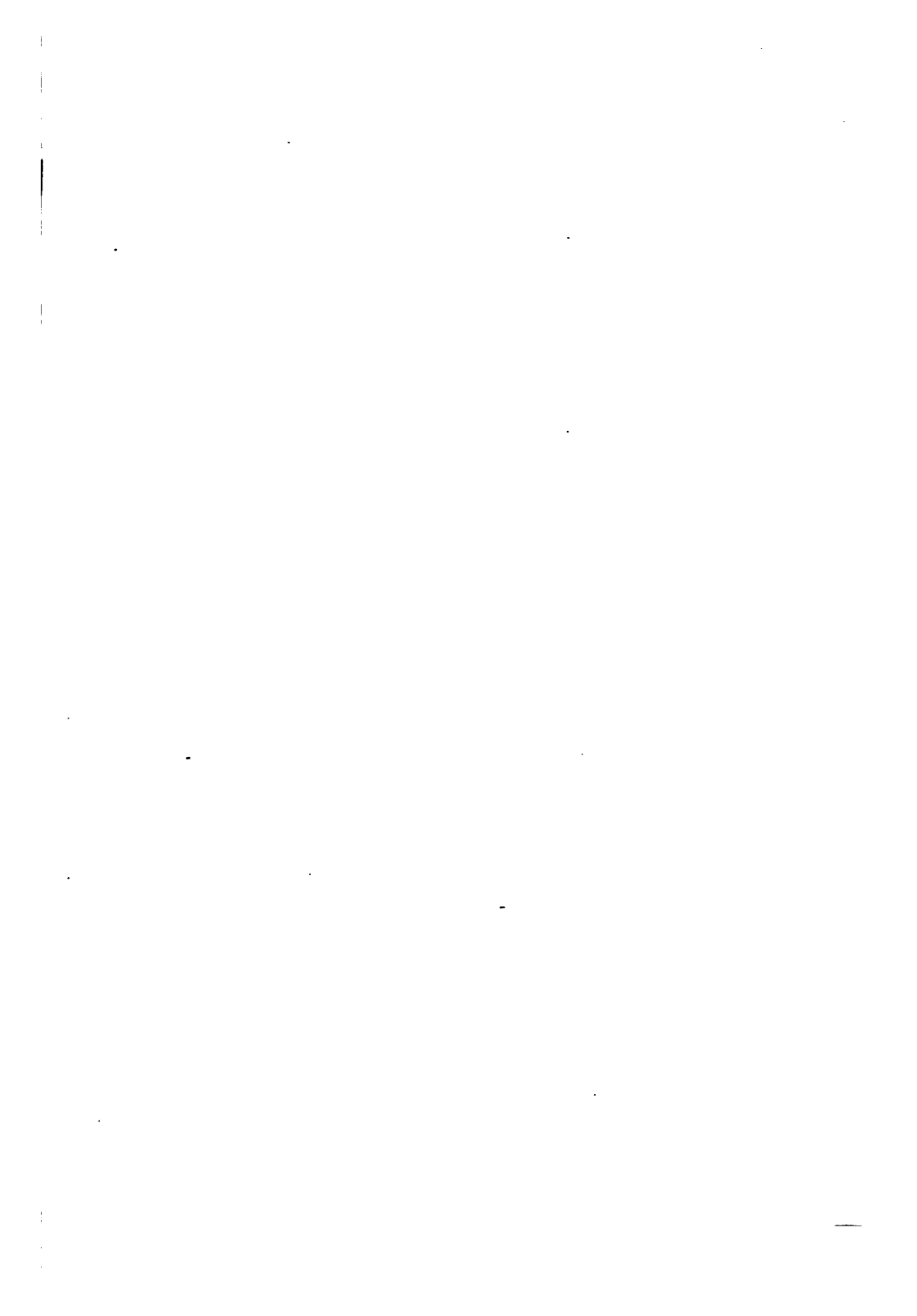
Prepare I like Br in the previous exp., using KI instead of KBr. Notice the difference in its action, color, state, etc., and give a full description with equation.

II. Properties and Tests.

(1) Make the same tests with starch as in Exp. 39, noting the different results. (2) Warm 1 or 2 crystals of I in a *dry* t.t. Notice the color of vapor, and its relative weight (pour a little into a dry e.d.). (3) While warming the tube hold a s.r. half way down the t.t. Look for a sublimate on the rod and on the sides of the tube, examining carefully its form, luster, and color. (4) Put into a small t.t. 1 or 2 crystals of I, add 3 or 4^{cc} of alcohol, C_2H_5OH , and warm a minute. Explain, then (5) add a drop of this with a s.r. to a drop of starch sol. shaken up with 10 or 15^{cc} of H_2O . Observe the color of the product (starch iodid), and boil it a moment to see whether the color disappears. If not, too much I was used. When it is cool (hold the tube under a jet of water) observe again.

Supplementary. — (a) See whether a crystal of I will dis. in H_2O . To determine this apply the starch test. (b) To 5 or 10^{cc} H_2O add a drop or two of CS_2 and of KI sol. (examine), then one drop of euchlorin. Shake well, let stand, and note the color of the CS_2 globule. (c) Test the solubility of I in ether ($C_2H_5)_2O$, keeping the latter away from the flame. (d) Obtain crystals by letting the ether sol. evaporate. (e) To 10^{cc} H_2O add a few drops KI sol. and a few drops of starch paste. Shake well together and note the color. Now add *one drop* of euchlorin (Exp. 38). If too much euchlorin is added the sol. becomes green or black (ppt. of I). Describe the coloration and explain fully. (f) Repeat (e) of Exp. 39 with KI sol.

Terms: Sublimation, sublime, crystal, tincture.



41. EXPERIMENTS WITH SULFUR.

I. Crystallization.

Into a small beaker or large t.t. put 10 or 15^g S, and slowly melt it over a lamp (using sand bath or asbestos), not allowing it to become darker than amber-color. When it is melted remove the lamp, leave the beaker in position (or hold the t.t. in the hand), and when crystals begin to shoot across the surface, pour the liquid S remaining into water in an e.d. Explain.

Loosen the S by pouring round the edges a little HNO_3 . Warm if necessary, when the mass may be removed with a thin knife-blade.

II. Allotropy.

Put 10^g S into a t.t. and *slowly* melt it. Notice the yellow color, and see that the liquid (now above 100°) is very thin. Slowly continue to heat it till it becomes black. Note that it is now very thick and can scarcely be poured (about 200°). Apply more heat till it grows thin again (above 300°). Now heat to boiling (over 400°), note the color of the vapor, and any sublimate on the t.t. If it takes fire (S burns at 230°), cover the mouth of the tube with paper or cardboard for a minute. Pour the S into an e.d. of water. Pull it and note its elasticity. Is it now crystalline, or amorphous? See whether it afterward changes. Clean the t.t. as before.

III. Solubility.

Place in an e.d. $\frac{1}{2}$ ^g pulverized brimstone and cover it with CS_2 (avoid a flame, as CS_2 is explosively inflammable). See whether any dissolves. Let it stand till the CS_2 has evaporated, watching it meantime. Describe fully the phenomena.

Supplementary. — (a) Try to dis. a little S in ether, $(\text{C}_2\text{H}_5)_2\text{O}$, and let it evaporate. Is S soluble in H_2O ? (b) Grind together on a brick with a pestle or other implement, not over a half gram of S and KClO_3 . (c) Make gunpowder by mixing intimately very fine KNO_3 , C, and S (a small quantity of each). Pile the mixture on a brick and cautiously set it on fire. If this reaction is correct, in what proportion should the constituents be mixed: $2\text{KNO}_3 + 3\text{C} + \text{S} = \text{K}_2\text{S} + 3\text{CO}_2 + 2\text{N}$? (d) Obtain flowers of S by sublimation and see whether they are crystalline or globular (use compound microscope). (e) Add HCl to a sol. of $\text{Na}_2\text{S}_2\text{O}_3$ and look for a S ppt. (f) Obtain SO_2 from S, also from H_2SO_4 . (g) Try to bleach with it a green leaf or a blue petal.

Terms: allotropy, allotropic, fusion, crystalline, globular, amorphous.

42. HYDROGEN SULFID.

I. Preparation and Tests.

(1) Put into a gen. (rec. or t.t.) 5^g FeS, 10^{cc} H₂O, and 5^{cc} HCl (or H₂SO₄). Adjust a d.t., having the joints perfectly tight, and pass the gas for a minute or two into 5^{cc} H₂O in another t.t. or beaker (Fig. 36). Note the odor. Can you determine whether the gas is soluble in H₂O? (2) See whether the sol. is acid, alkaline, or neutral. With a s.r. put a drop of

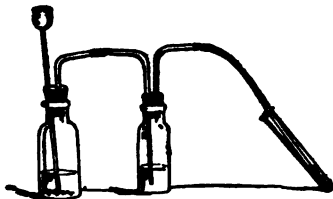


Fig. 36.

H₂S sol. on bright coins of (3) Ag and (4) Cu. State the effect, products, reactions. (5) Put a drop of Pb(C₂H₃O₂)₂ sol. on paper and pass the gas over it from the tube of the generator. Describe the effect (this is the characteristic test for H₂S) and write the equation. Is there any other way in which you would recognize this gas? (6) Try the combustibility of H₂S, using a philosopher's lamp. (7) If it burns, hold a glass tube or a crayon in the flame. Explain.

II. As a Reagent.

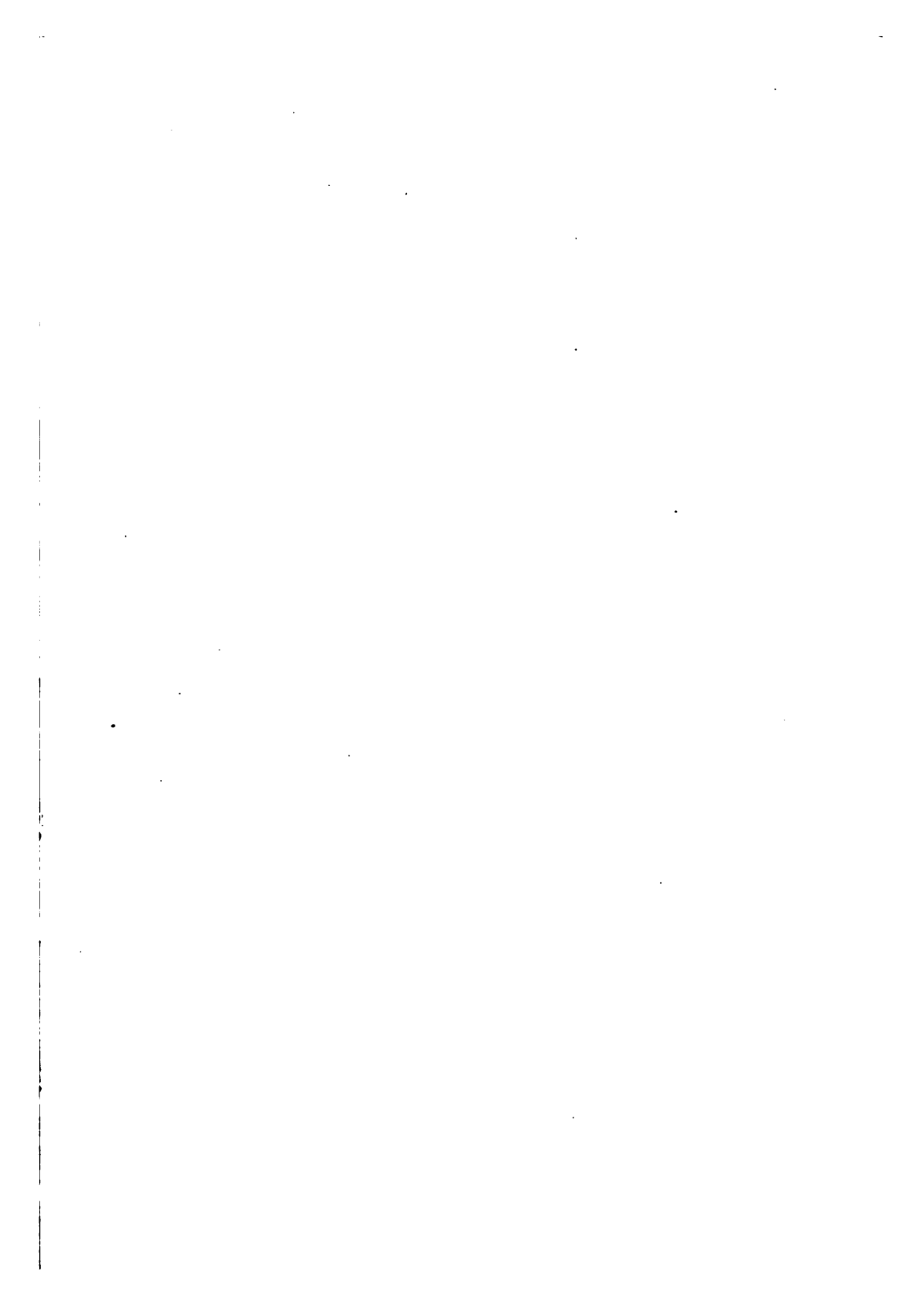
Add a little H₂S sol. to 5^{cc} of each of the following sols., describe the results, write equations where necessary, and explain why there is no effect in certain cases: (1) HgCl₂, (2) CuCl₂, (3) BaCl₂, (4) CaCl₂. (5) Next mix 3 or 4^{cc} CuCl₂ sol. and the same quantity of BaCl₂ sol., add H₂S sol., shake it well and filter. What is the residue and what does the filtrate contain? (6) Now to the filtrate add a sol. of Na₂CO₃. State the effect, give the reaction, and explain how the Cu and the Ba have been separated.

III. Test for Sulfids.

To a little Na₂S or CaS add H₂SO₄. If any gas arises (heat if necessary) try the Pb(C₂H₃O₂)₂ test.

Supplementary. — See whether you can separate (a) Cu from Ca; (b) Ca from Hg; (c) Hg from Ba; (d) Fe from Cu. How are some insol. sulfids made? (e) Test FeS for a sulfid? What sulfids are insoluble?

Terms: sulfuretted hydrogen, sugar of lead, sulfid.



43. PHOSPHORUS.

Caution: Phosphorus must be handled with forceps, as the burns from it heal very slowly, and all experiments with it must be done cautiously. None should be dropped upon the floor, nor left upon the apparatus, and all must finally be burned. CS_2 must be kept away from the flame.

I. Spontaneous Combustion.

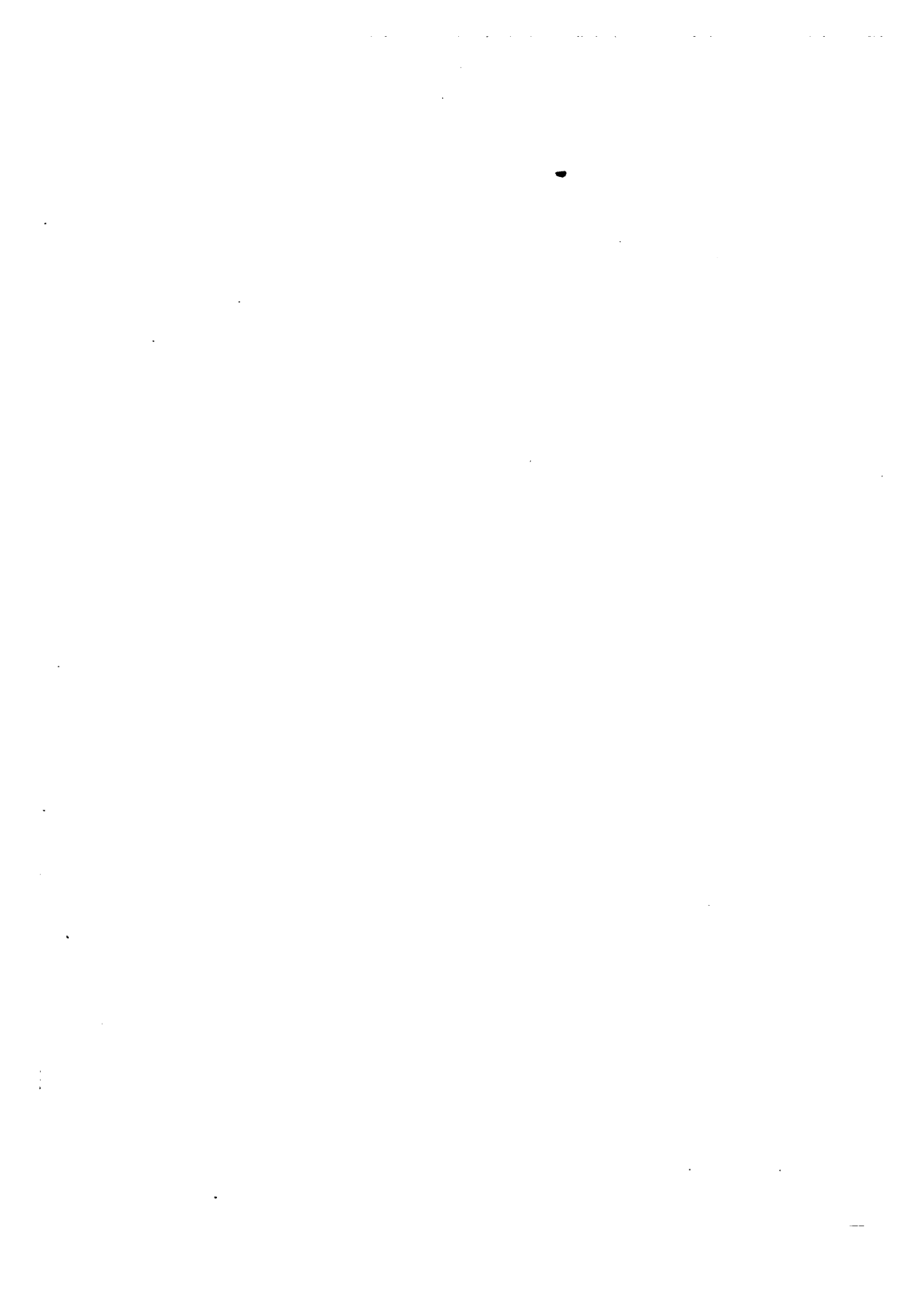
(1) Into an e.d. put 10 or 20^{cc} of CS_2 (for a class) and drop into it 3 or 4 small pieces of P. Notice the odor of CS_2 and whether the P dissolves in it. Also observe the color and luster of newly cut P. (2) Dip a piece of unglazed paper into the sol., then place it on the ring of a r.s. till it is dry, looking out for any action. If such occurs *state fully what has caused it* and whether it is a case of ordinary combustion.

II. Combustion under Water.

Put into a large t.t. 4 or 5 crystals of KClO_3 , cover it with H_2O and add a small piece of P. Rest the t.t. in a rec., and then slowly add 2 or 3^{cc} H_2SO_4 through a thistle tube which reaches to the P and KClO_3 . Account for the phenomena. What color is the liquid, and what is the cause of it? HKSO_4 , HClO_4 , ClO_2 and H_2O are formed. Write the equation for forming them, and for the combustion. What compound of P is finally formed?

Supplementary. — (a) Put a small piece of P into a dry e.d. in a dark room, observe, and explain the result. (b) Put a piece of P on a *dry* plate or e.d., set it on fire and at once cover with a dry inverted rec. When the fumes settle add a very little water. Test the product with litmus. (c) Cover a small piece of P with bone black in a plate, and leave for some time. If no action ensues burn the P before leaving the Exp.

Terms: spontaneous combustion, phosphorescence.



44. ARSENIC.

I. Marsh's Test.

Caution: AsH_3 is a deadly poison, and must not be inhaled. If the H is ignited before introducing the As compound there is little danger.

Prepare a hydrogen gen., with or without a CaCl_2 drying attachment, and with lamp tube (Fig. 37, or model). Put in a few pieces of arsenic-free Zn, some distilled water, and c.p. HCl . After a few minutes test the H gas (Exp. 13) before lighting, and when no sharp explosion occurs light the gas, and observe the color of the flame. Test for As by holding an e.d. over the

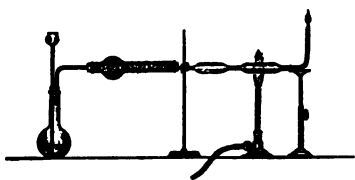


Fig. 37.

flame. Now pour through the thistle tube 1 or 2^{cc} of a sol. that may be supposed to contain some cpd. of As. This sol. may be obtained either by dissolving HNa_2AsO_3 in H_2O with a little HCl , or by immersing in HCl a small piece of green paper tag from which any As that may be present will dis. as AsCl_3 . Note any change in the color of the flame; hold an e.d. or other cold body in the flame and look for a deposit; put a Bunsen flame under the drawn out tube (Fig. 37) and look for a sublimate just beyond. Absence of a sublimate in either case indicates absence of As. Explain fully, writing all equations.

II. Reinsch's Test.

Into a sol. of an As salt (obtained by HCl as above) in a beaker or e.d. put a small strip of bright Cu foil and heat for a few minutes. Notice that the foil changes color. After a few minutes remove it, dry it by carefully pressing between folds of blotting paper, cut it into strips, and put them into a t.t.; heat the latter. Notice the vapor and sublimate, As_4O_6 , on the tube. This sublimate may be examined under the microscope after first breaking the tube. Explain all results, using equations.

Supplementary. — (a) Reduce As_4O_6 as follows: Mix intimately a bit of it not larger than a wheat grain with as much powdered charcoal, put the mixture into a small t.t. or i.t. and heat strongly. Note the vapor, color, sublimate. (b) Make Scheele's green by mixing sols. of CuCl_2 and HNa_2AsO_3 (or other sol. cpds.) and having them nearly neutral. (c) Try the effect on these mixtures of (d) excess of HCl , (e) excess of NH_4OH . (f) See whether As_4O_6 is very soluble in H_2O by putting a *very little* into a t.t. and heating with H_2O . (g) Heat a little powdered arsenopyrite, FeAsS , in a t.t. and note the odor. (h) Test some wall paper, or colored silk, for As.

45. COMPOUNDS OF BORON.

I. Boric Acid.

Put 5^g of $\text{Na}_2\text{B}_4\text{O}_7$ into a t.t., add 10^{cc} of dil. H_2SO_4 and boil till it is clear, adding more water if necessary. Then cool it by holding the tube under a jet of water, keeping watch for crystals. When it is cool pour off the supernatant liquid and rinse the crystals once or twice with water to remove the H_2SO_4 , then put them into an e.d. Add a very little water, and when the crystals have dissolved dip into the sol. a piece of turmeric paper, which should then be dried and the color noted. Describe fully the results.

II. Borax Beads.

Make a loop in the end of a Pt wire (which is welded into a short glass tube, Fig. 38). Moisten the loop end and dip it into some powdered borax, $\text{Na}_2\text{B}_4\text{O}_7$. Now heat it, using the mouth blowpipe, dipping it again into the borax if more is wanted, and heating till a clear transparent bead is obtained. Describe and explain the phenomena. Beads may be colored as follows: If blue is wanted dip the clear bead into a very dil. sol. of some Co salt, as CoCl_2 , and fuse again. (If too much Co is used it will look dark.) For other colors v. Table G. Detach the beads by suddenly jerking the Pt wire while the bead is fused. Save the beads, and label them, stating the coloring material.

Supplementary. — (a) See whether H_3BO_3 is more, or less, soluble in hot water than in cold. (b) Make a bead of H_3BO_3 if possible. (c) Stir a little H_3BO_3 in an e.d. with a few drops of $\text{C}_2\text{H}_5\text{OH}$. Then take some of the mixture on a short glass tube and hold it in a Bunsen flame, noting the color imparted to the latter. (d) Try the same with $\text{Na}_2\text{B}_4\text{O}_7$, (e) then with $\text{Na}_2\text{B}_4\text{O}_7$ to which has been added a few drops of H_2SO_4 .

Terms: borax bead, flux.



46. COMPOUNDS OF SILICON.

I. Silicic Acid and Silica.

Pour a few cubic centimeters of water glass, H_4SiO_4 , into an e.d. and add a little HCl . Note the phenomena, describe the result and write the equation. Pour off the extra HCl and rinse the residue, H_4SiO_4 , 2 or 3 times with H_2O . Now heat it over a Bunsen flame, with stirring. This leaves SiO_2 . Write the equation, and note how the product feels when rolled between the fingers. Is silicic acid made differently from other acids? Pulverize (in a mortar if necessary) some of the SiO_2 obtained, to use in the following.

II. Silicates by Solution.

Make a strong sol. of NaOH (or KOH) and add to it some of the SiO_2 obtained above, very finely powdered. Heat and stir the mixture for some time. See whether the SiO_2 dissolves, and write an equation.

III. Silicates by Fusion, Glass.

Make a small mixture of equal parts of powdered Na_2CO_3 and K_2CO_3 and fuse the mixture into a bead as in the case of borax. Note that the bead is opaque when cold. Is it so when hot? Dip this bead when hot into a little SiO_2 powdered very finely, then heat again more strongly in the hottest part of the flame. If it is not transparent when cold, dip it again into the SiO_2 and heat more strongly than before. See whether it now resembles glass. Describe all phenomena and write the equations. Colors may be obtained as in borax beads, Table G.

Supplementary. — (a) Try to dis. finely powdered SiO_2 in a strong sol. of Na_2CO_3 , boiling the mixture. (b) Try to fuse SiO_2 in a borax bead.

Terms: fusible, infusible, fusion, transparent, opaque, silica, silicate, glass, water glass.

47. OXIDATION AND REDUCTION.

I. Oxidation.

(1) Into each of two tubes put 5^{cc} FeSO_4 sol. (freshly dissolved). To one of these add a few drops HNO_3 and boil a minute, then cool. To each of the tubes add 5^{cc} NaOH sol. (or NH_4OH). Observe the color effects, explain their causes, and give equations for the ppts. Explain the action of HNO_3 .

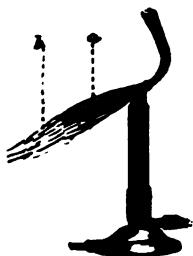


Fig. 39.
a, reducing flame.
b, oxidizing flame.

(2) Put a small fragment of Pb on a piece of charcoal, slightly hollowed out with the handle of the forceps. Fit a metallic tube to a Bunsen burner, and with a mouth blow-pipe blow the *oxidizing flame* (outer) *strongly and steadily* against the Pb for 4 or 5 minutes (Fig. 39). What first takes place? As you stop blowing, notice the yellow vapor that escapes from the globule of Pb: also the yellow coating of PbO on the charcoal. Explain fully, using equations.

II. Reduction.

(1) Pour a little FeCl_3 sol. into two tubes. Pass SO_2 gas, or H, from a gen. into one of these for a few minutes. Next add NH_4OH to each. Compare the products and explain, with equations. What action has the SO_2 or the H? Try the action of Zn and H, or of Zn alone.

(2) Put $\frac{1}{4}$ PbO on a piece of charcoal hollowed out as before. With the blow-pipe blow the *reducing flame* (inner) steadily against it for some time, or until a metallic globule is obtained. What is it? Explain fully, with equation. See whether the globule is sectile (can be cut) or malleable (can be flattened by pressure). *Extinguish the fire*, if the coal still glows, *with a drop of water*.

Supplementary. — Notice that the action of the flames here is like that of oxidizing and reducing agents generally. (a) Experiment with other metals and oxids. (b) See whether Fe(OH)_2 or Fe(OH)_3 tends to change to the other on standing. Which is the more stable cpd.? (c) Try sols. of FeSO_4 and FeCl_3 in the same way. (d) Try to oxidize FeSO_4 sol. with a little euchlorine. (e) Oxidize HgNO_3 with HNO_3 . (f) Try to reduce $\text{K}_2\text{Cr}_2\text{O}_7$ sol. to CrCl_3 with a little HCl , $\text{C}_2\text{H}_5\text{OH}$ and heat. Note the change in color, also test by Exp. 48. Are these oxidizing, or reducing agents: (g) KClO_3 , (h) KNO_3 , (i) C, (j) Cu? (k) Pulverize about a gram of KNO_3 and mix it with a like quantity of fine charcoal. Put into a dry i.t. and heat. (l) Try KNO_3 and S in the same way.

Terms: Oxidation, reduction, oxidizing agent, reducing agent, oxidizing flame, reducing flame.

IONS.

COLOR.	SOL.
white	(a) PbCl_2
yellow	

H_2O , hence traces of it are in a sol. the $\text{K}_2\text{Cr}_2\text{O}_7$ test is what other Pb salt might be water sol. of PbCl_2 to cool which is the stronger cpd. for Pb.

IONS.

REMARKS.
With PbAc_2 no ppt., Pb_2OAc_2 being sol.
Re-ppts., cryst., on cooling.
HNO_3 (str.) forms PbSO_4 .
$\text{H}_2\text{S} + \text{HNO}_3$ ppts. S.
HNO_3 (str.) forms PbSO_4 .
$\text{Am}_2\text{S} + \text{HNO}_3$ ppts. S.
Re-ppts., cryst., on cooling.
Dis. by $\text{Na}_2\text{S}_2\text{O}_3$ (v. BaSO_4).
HCl changes ppt. to PbCl_2 .
Boiling re-ppts.
Also Al, Cd, Co, Mg.
Yel. PbO on C.C.

49. SILVER, Ag.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. AgCl (v. Pb, Hg') To AgNO ₃ sol. add HCl, filter (test fil.), wash res., reject fil. and washings.	(1) AgCl	white	
2. Dis. AgCl in NH₄OH (v. Hg', Pb). To (1) add NH ₄ OH on filter, and catch fil. in t.t.			(a) (NH ₄) ₂ (AgCl) ₂
3. Re-ppt. AgCl. Cautiously acidify (a) with HNO ₃	(2) AgCl	white	

Supplementary. — 1. Strong HCl dis. AgCl (and HgCl somewhat); hence avoid excess. 2. In testing for *trace* of Ag, evap. NH₃ before adding HNO₃. 3. Never add the latter in large excess. AgCl is not re-pptd. by HCl except in conc. sols. (a) Sep. Ag from Pb. Are most salts of Ag soluble (Table A)? Can these exist together in sol: (b) AgNO₃ and HgCl₂? (c) AgNO₃ and CuCl₂?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENT.	REMARKS.
1	AmOH	Ag ₂ O	brown	{ AmOH (ex.), KCy, Na ₂ S ₂ O ₃ , HAc, H ₂ SO ₄	AgOH is not known.
2	NaOH	"	"	"	
3	Am ₂ CO ₃	Ag ₂ CO ₃	white	Am ₂ CO ₃ (ex.), AmOH, HNO ₃	
4	Na ₂ CO ₃	"	"	"	
5	HCl	AgCl	"	{ AmOH, KCy, Na ₂ S ₂ O ₃ , boiling HNO ₃	HNO ₃ re-ppts. Light reduces to Ag ₂ Cl, violet, black.
6	H ₂ S	Ag ₂ S	black	"	
7	Am ₂ S	"	"	"	
8	KBr	AgBr	white	AmOH (sl.)	
9	KI	AgI	{ yellow- white	KI (ex.)	Insol. in AmOH.
10	K ₂ Cr ₂ O ₇	Ag ₂ CrO ₄	{ dark red	{ AmOH, HNO ₃	HCl changes it to AgCl.
11	Am ₂ Ox	Ag ₂ Ox	white	AmOH	
12	HN ₃ P ₂ O ₄	Ag ₃ P ₂ O ₄	yellow	{ AmOH, HNO ₃	
13	KCy	AgCy	white	KCy (ex.)	
14	K ₂ FeCy ₄	Ag ₂ FeCy ₄	{ yellow- white		Boiling gives metallic Ag.
15	Zn	Ag	gray	dil. HNO ₃	Also Bi, Cu, Fe, Hg, Pb.
16	{ Na ₂ CO ₃ , B.B.C.C. }	Ag	"	HNO ₃	Metallic globule.

50. MERCURY (ous), Hg'.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. HgCl (v. Ag, Pb). To HgNO ₃ sol. add HCl, filter (test fil.), wash, reject fil. and washings.	(1) HgCl	white	
2. AmOH on HgCl (v. Ag, Pb). On (1) pour a little AmOH, wash and reject washings.	(2) NH₂Hg₂Cl	black	
3. Dis. NH₂Hg₂Cl in aqua regia. On (2) pour a few drops aqua regia, save fil.			(a) HgCl₂
4. Re-ppt. HgCl. Dilute (a), add SnCl ₂ sol.	(3) HgCl Hg	white gray	

Supplementary. — 1. Hg', not Hg'', must be used as HgCl₂ is sol. 3. The smallest quantity of *aqua regia* that will dis. the ppt. must be used. 4. SnCl₂ sol. must be newly prepared, and with plenty of HCl, or it will oxidize to SnCl₄ and Sn₂OCl₂. (a) Sep. Hg' from Ag. (b) Hg' from Pb. Explain action of SnCl₂ on HgCl₂. (c) Can HgNO₃ and CuCl₂ exist in sol. together? (d) HgNO₃ and CdCl₂?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	NH ₂ Hg ₂ NO ₃	black	HNO ₃ , aq. reg.	Hg ₂ O (instable) = Hg + HgO. HgOH not known.
2	NaOH	Hg ₂ O	{ brown- black	" "	
3	Am ₂ CO ₃	NH ₂ Hg ₂ NO ₃	black	Acids.	Forms black Hg ₂ O on boiling. With AmOH = NH ₂ Hg ₂ Cl (black).
4	Na ₂ CO ₃	Hg ₂ CO ₃	gray		
5	HCl	HgCl	white	HNO ₃	Hg ₂ S (instable) = HgS + Hg
6	H ₂ S	Hg ₂ S	black	aq. reg.	
7	Am ₂ S	"	"	"	Ex. forms HgI ₂ (sol.) + Hg. Acids decompose it. In strong sol. only.
8	KI	HgI	{ yellow- green	KI (ex).	
9	H ₂ SO ₄	Hg ₂ SO ₄	white	HNO ₃	Hg ppd.
10	K ₂ Cr ₂ O ₇	Hg ₂ CrO ₄	yellow	HNO ₃	
11	Am ₂ Ox	Hg ₂ Ox	white	"	Also Al, Bi, Cd, Cu, Mg. Sn amalgamates with M. Heat in tube with Na ₂ CO ₃ + C, and Hg sublimes.
12	HNa ₂ PO ₄	Hg ₂ PO ₄	"	"	
13	KCy	HgCy ₂ + Hg	gray	H ₂ O	
14	K ₂ FeCy ₆	Hg ₂ FeCy ₆	white	HNO ₃	
15	Zn.	Hg	gray	HNO ₃ , aq. reg.	
16	Na ₂ CO ₃ , { B.B.C.C. }	Hg	"	" "	

51. GROUP I. — Pb'', Ag', Hg'.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	SOL.
1. Ppt. PbCl₂, AgCl, HgCl. Sat. sol. with HCl, filter, wash, reject washings.	(1) PbCl₂, AgCl, HgCl	
2. Sep. Pb from Ag, Hg. On (1) pour boiling H ₂ O. Repeat till last fil. gives no ppt. with K ₂ Cr ₂ O ₇ sol.	(2) AgCl, HgCl	(a) PbCl₂
3. Final test for Pb. To (a) add K ₂ Cr ₂ O ₇ sol. (or K ₂ Cr ₂ O ₄).	(3) PbCrO₄	
4. Sep. Ag. from Hg. On (2) pour warm AmOH two or three times.	(4) NH₂Hg₂Cl	(b) (NH₄)₂(AgCl)₂
5. Final test for Ag. Acidify (b) with HNO ₃ .	(5) AgCl	
6. Dis. NH₂Hg₂Cl. To (4) add very little aqua regia.		(c) HgCl₂
7. Final test for Hg. To (c) add SnCl ₂ sol.	(6) HgCl, Hg	

Supplementary. — 1. Avoid large excess of HCl, as it may interfere with the ppts. of H₂S, Grp. II. AgCl is less sol. than HgCl, HgCl than PbCl₂. HCl may give a ppt. outside of Group I as follows: of S, if a sulfid or thiosulfate is present; of BaCl₂ (sat. sol.) which is sol. in H₂O but insol. in strong HCl; of BiOCl, SbOCl, Sn₂OCl₂, from sols. acidified with other acids than HCl (these are sol. in excess of HCl); of As₂S₃, Sb₂S₃, SnS₂, AgCy, NiCy₂, H₄SiO₄, H₃BO₃, Zn(OH)₂, Al(OH)₃, from an alk. sol. In any of the above cases if an appreciable ppt. falls, insol. in H₂O or HCl, dis. and analyze separately. 2. PbCl₂ should all be removed by successive additions of hot H₂O (test the last fil. with a drop of AgNO₃ sol.), as NH₄OH changes it to white insol. Pb₃OCl₂, some of which appears in the fil. HNO₃ however dis. it. It may be better to boil the liquid which holds the first ppt. before filtering, then filter and test the fil. for Pb. 3. What other reagent might be used here? 4. Why is not AgNO₃ formed? I have a white powder which is PbCl₂, HgCl, or AgCl. What reagent will determine which it is?

52. MERCURY (1c), Hg''.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. HgS (v. Pb, Bi, Cd, Cu, As, Sn, Sb). Sat. sol. with H ₂ S gas, filter (test fl.), wash.	(1) HgS	black	
2. HgS insol. in Am₂S_x (v. As, Sn, Sb). To (1) in e.d. add Am ₂ S _x , stir, boil, decant, wash.	(2) HgS	"	
3. HgS insol. in dil. HNO₃ (v. Pb, Bi, Cd, Cu). Cover (2) with dil. HNO ₃ , boil a minute, decant.	(3) HgS	"	
4. Dis. HgS in aqua regia (v. Hg'). To (3) add little aqua regia, stir, boil if necessary.	(S)		(a) HgCl₂
5. Ppt. HgCl and Hg with SnCl₂ (v. Hg', Sn''). Boil (a) to expel all Cl, add SnCl ₂ sol.	(4) HgCl Hg	white gray	

Supplementary. — 1. Hg'' salts often give with H₂S a ppt. first white, then yellow, red, brown, black. Double salts., e.g. HgCl₂(HgS)₂ are first formed. 3. Strong HNO₃ may convert HgS into Hg(NO₃)₂(HgS)₂, white, insoluble; hence test a white res. for Hg. 4. In dis. HgS use the smallest quantity of aqua regia (usually only a few drops). The sol. may afterwards be diluted. 5. SnCl₂ sol. is pearly, and must not be confounded with a Hg ppt. How detect HgNO₃ in a mixture with Hg(NO₃)₂? Hg(NO₃)₂ in presence of HgNO₃? Explain the action of SnCl₂ on HgCl₂. Is HgS sol. in strong HNO₃? Why is Hg'' not put into Group I?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	NH ₂ HgCl	white	AmOH, HCl	Hg(NO ₃) ₂ gives NH ₂ NO ₃ . Hg(OH) ₂ not known.
2	NaOH	HgO	yel.-red	HNO ₃	
3	Am ₂ CO ₃	NH ₂ HgCl	white	AmOH, HCl	Forms HgO on boiling.
4	Na ₂ CO ₃	(HgO) ₂ HgCO ₃ (var.)	{ red white		
5	SnCl ₂	HgCl, Hg	gray	HNO ₃ , aq. reg.	May be first white, then red, brown, black.
6	H ₂ S	HgS	black	aqua regia	
7	Am ₂ S	"	"	"	
8	KBr	HgBr ₂	white	hot H ₂ O	
9	KI	HgI ₂	red	{ HgCl ₂ KI (ex.), HCl	With HgCl ₂ no ppt. forms.
10	K ₂ Cr ₂ O ₇	HgCrO ₄	orange	HNO ₃	
11	Am ₂ Ox	HgOx	white	dil. HNO ₃	
12	HN ₃ PO ₄	Hg ₃ (PO ₄) ₂	"	acids, Am. salts	
13	KCy	HgCy ₂	"	KCy (ex.)	On stand. becomes Pruss. blue. Forms amalgam with the metal (v. Exp. 50).
14	K ₄ FeCy ₆	Hg ₂ FeCy ₆	"		
15	Zn	Hg	gray		
16	Na ₂ CO ₃ } B.B.C.C. }	Hg	"		

53. LEAD, Pb'.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. PbS (v. Hg'', Bi, Cd, Cu, As, Sn, Sb). Sat. sol. with H ₂ S, filter (test fl.), wash.	(1) PbS	{ brown- black	
2. PbS insol. in Am₂S_x (v. As, Sn, Sb). To (1) in e.d. add Am ₂ S _x , warm, decant, wash.	(2) PbS	"	
3. Dis. PbS in HNO₃ (v. Hg''). Boil (2) with dil. HNO ₃ , evap., add H ₂ O.			(a) Pb(NO ₃) ₂
4. Ppt. PbSO₄ (v. Bi, Cd, Cu). To (a) add dil. H ₂ SO ₄ + C ₂ H ₅ OH, and shake it.	(3) PbSO ₄	white	

Supplementary. — 1. Pb sometimes gives colored ppts. at first, like Hg'', if much HCl is present. If there is much mineral acid, it must be diluted or partly neutralized before H₂S will give a ppt. 3. Strong HNO₃ oxidizes PbS to PbSO₄, and dil. acid does so somewhat. Some PbSO₄ dis. in HNO₃, and some may be left with HgS. Test the latter with boiling AmAc sol., filter and add HAc + K₂Cr₂O₇ sol. Before adding H₂SO₄ all HNO₃ should be expelled by evaporation. (a) Sep. Hg'' from Pb. Test the relative solubility in water of (b) PbCl₂, (c) PbS, (d) PbSO₄. Can these salts exist together in a sol.: (e) Pb(NO₃)₂ + MgSO₄? (f) Pb(NO₃)₂ + Na₂CrO₄? (g) Pb(NO₃)₂ + NaCl? Explain. Exp. 48 gives General Reactions for Pb.

54. BISMUTH, Bi'''.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Bi₂S₃ (v. Hg, Pb, Cd, Cu, As, Sb, Sn). Sat. sol. with H ₂ S, filter, wash.	(1) Bi₂S₃	{ brown- black	
2. Bi₂S₃ insol. in Am₂S_x (v. As, Sn, Sb). To (1) add Am ₂ S _x .	(2) Bi₂S₃	"	
3. Dis. Bi₂S₃ in HNO₃ (v. Hg.). To (2) add dil. HNO ₃ , boil a minute, filter.	(3)		(a) Bi(NO₃)₃
4. Bi not ppt. by H₂SO₄ (v. Pb). To (a) add few drops H ₂ SO ₄ .			(b) Bi(NO₃)₃
5. Final test for Bi (v. Cd, Cu). To (b) add excess AmOH, shake, let stand.	(3) Bi(OH)₃	white	

Supplementary. — 1. Diluting an acid sol. of Bi may ppt. BiOCl, BiONO₂, etc., but H₂S changes these to Bi₂S₃. 5. NH₄OH must be added in excess, otherwise Bi will not ppt. here, but with Cd (v. Group II, A). (a) Pour a few drops of the BiCl₃ sol. into a t.t. of H₂O. BiCl₃ reacts with H₂O, and forms insoluble BiOCl (v. Sb). (b) Test Bi(NO₃)₃ sol. in the same way. BiNO₃(OH)₂ (variable) is ppd. Name the ppts. Try to dis. them with acids: (c) HCl, (d) HNO₃, (e) HAc. Most salts of Bi react with H₂O. This confirmatory test may be tried in analysis. Ppt. (f) a Bi salt and (g) a Pb salt (in 2 tubes) with K₂Cr₂O₇ sol., and test solubility of each in NaOH sol. What would this reaction distinguish? Now add SnCl₂ sol. to each. (h) Sep. Bi from Hg''; (i) Bi from Pb; (j) Bi from Ag.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Bi(OH) ₃	white	Acids	Boil. gives Bi ₂ O ₃ (yel.-wh.).
2	NaOH	"	"	"	No. ppt. with H ₂ Tr or H ₂ Cl.
3	Am ₂ CO ₃	Bi ₂ O ₃ CO ₃	"	"	
4	Na ₂ CO ₃	"	"	"	
5	SnCl ₂	BiO	black		With excess NaOH (v. Cl).
6	H ₂ S	Bi ₂ S ₃	"	HNO ₃ (dil.)	Insol. in Am ₂ S _x .
7	Am ₂ S	"	"	"	" " "
8	KI	{ BiOD BiI ₃	{ dark brown	HCl	
9	H ₂ O	BiOCl	white	HCl	Others give basic salt.
10	K ₂ Cr ₂ O ₇ }	Bi ₂ O(CrO ₃) ₂	yellow	HNO ₃	Insol. in NaOH (v. Pb).
11	or K ₂ CrO ₄ }				
12	Am ₂ Ox	Bi ₂ Ox ₃	white	HNO ₃	
13	HN ₃ P.O.	BiPO ₄	"	HCl	Insol. in HNO ₃ or HAC.
14	KCy	Bi(OH) ₃	"	Acids	Insol. in excess KCy.
15	K ₄ FeCy ₆	Bi ₄ FeCy ₁₂	{ yellow- white	HNO ₃	Reppts. on boiling.
16	Zn	Bi	spongy	"	Also Cu, Fe, Pb, Sn.
17	Na ₂ CO ₃ }	Bi	dark	"	Incrustation yellow.
	B.B.C.C.				

55. CADMIUM, Cd⁺⁺.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. CdS (v. Hg, Pb, Bi, Cu, As, Sb, Sn). Sat. sol. with H ₂ S; filter, wash.	(1) CdS	yellow	
2. CdS insol. in Am₂S_x (v. As, Sb, Sn). To (1) add Am ₂ S _x in e.d.; stir.	(2) CdS	yellow	
3. Dis. CdS in HNO₃ (v. Hg). Boil (2) a minute with dil. HNO ₃ . Filter if necessary.	(S)		(a) Cd(NO₃)₂
4. Cd not pptd. by H₂SO₄ (v. Pb). To (a) add a drop or two dil. H ₂ SO ₄ .			(b) Cd(NO₃)₂
5. Cd(OH)₂ dis. by excess AmOH (v. Bi). To (b) add excess. AmOH.			(c) (NH₄)₂CdO(AmNO₃)₂
6. Cd not pptd. by KCy (v. Cu). To (c) add little KCy sol.			(d) (KCy)₂CdCy₂
7. Re-ppt. CdS (v. Cu). Sat. (d) with H ₂ S.	(3) CdS	yellow	

Supplementary. — 1. If a large excess of acid is present the sol. must be diluted before H₂S will act. (a) Sep. Cd from Bi. (b) Sep. Cd from Hg⁺⁺. (c) Sep. Cd from Pb. What sol. salts, if any, of Cd have the corresponding salts of Cu insol., or *vice versa* (v. Table A)? (e) Devise any method of separating Cd from Cu, dependent upon this, and try it.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Cd(OH)₂	white	AmOH(ex)	Insol. in excess.
2	NaOH	"	"	Acids	
3	Am₂CO₃	CdCO₃	"	"	
4	Na₂CO₃	"	"	"	
5	H₂S	CdS	yellow	{ Hot, dil. HNO₃	Free Am prevents. ppt.
6	Am₂S	"	"	"	
7	K₂Cr₂O₇	CdCrO₄	"	HNO₃	In concentrated sols. only.
8	Am₂Ox	CdOx	white	Acids(sol.)	
9	HN₃PO₄	Cd₃(PO₄)₂	"	Acids	Re-pptd. by H ₂ S.
10	KCy	CdCy₂	"	KCy(ex.)	
11	K₂FeCy₆	Cd₂FeCy₆	"	{ HCl AmOH	
12	K₂FeCy₆	Cd₂Fe₂Cy₁₂	yellow	{ AmOH HCl	
13	Zn	Cd	gray		Also Al, Mg.
14	Na₂CO₃ } B.B.C.C. }	CdO	{ brown- yellow		Incrustation, no globule.

56. COPPER, Cu⁺.

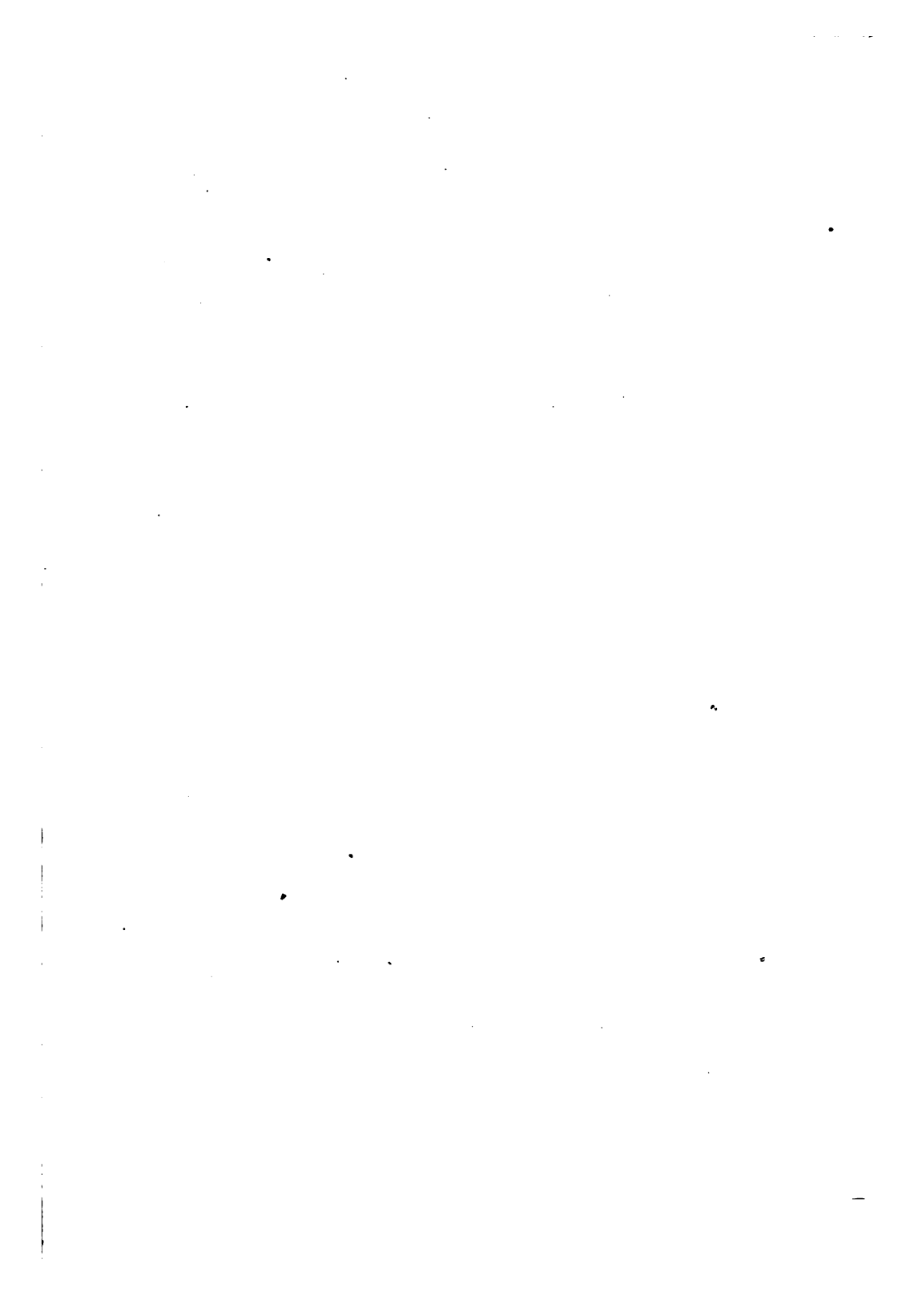
ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. CuS (v. Hg, Pb, Bi, Cd, As, Sb, Sn). Sat. sol. with H ₂ S, filter, wash.	(1) CuS	{ brown- black	
2. CuS insol. in Am₂S_x (v. As, Sb, Sn). To (1) add Am ₂ S _x ; stir.	(2) CuS	{ brown- black	
3. Dis. CuS in HNO₃ (v. Hg). To (2) add dil. HNO ₃ , boil a minute, filter if necessary.	(3)		(a) Cu(NO ₃) ₂
4. Cu not pptd. by H₂SO₄ (v. Pb). To (a) add a drop or two H ₂ SO ₄ .			(b) Cu(NO ₃) ₂
5. Cu salts sol. in excess AmOH (v. Bi). To (b) add excess AmOH.			(c) (NH ₄) ₂ CuO(AmNO ₃) ₂
6. Action of KCy on Cu salts (v. Cd). To (c) add KCy sol. until blue color disappears.			(d) (KCy) ₂ CuCy ₂
7. Inaction of H₂S on (KCy)₂CuCy₂ (v. Cd). Pass H ₂ S into (d).			(e) (KCy) ₂ CuCy ₂
8. Final test for Cu . To (e) add HCl.	(3) CuS	{ brown- black	

Supplementary. — 5. If the sol. does not become blue on adding NH₄OH, Cu is absent. 2. CuS dis. slightly in (NH₄)₂S_x. Neutralizing such a sol. with HCl gives a liver-colored ppt. (a) Sep. Cu and Pb; (b) Cu and Hg⁺; (c) Cu and Bi. (d) Can CuCl₂ exist in sol. with Na₂CO₃? (e) Cu(NO₃)₂ and Na₂S? (f) CuCl₂ and MgSO₄?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Cu(OH) ₂	blue	AmOH (ex.)	Unsat., pale-blue basic.
2	NaOH	"	"	"	Boiling gives black CuO.
3	Am ₂ CO ₃	Cu ₂ (OH) ₂ CO ₃	"	Am ₂ CO ₃ (ex.)	" " " "
4	H ₂ S	CuS	black	HNO ₃ , KCy	
5	Am ₂ S	"	"	"	
6	KI	CuI, I	yel.-wh.	KI (ex.)	
7	K ₂ CrO ₄	Cu ₂ CrO ₄ (OH) ₂	red-br.		
8	Am ₂ Ox	CuOx	{ blue- white	{ M. acids Am ₂ Ox(ex.)	
9	HN ₃ PO ₄	HCuPO ₄	"	Acids	Cu (ex.) gives Cu ₃ (PO ₄) ₂ .
10	KCy	CuCy ₂	gr.-yel.	KCy (ex.)	H ₂ S has no effect on KCy.
11	K ₂ FeCy ₆	Cu ₂ FeCy ₆	red-br.	AmOH	Dil. sol. gives red color.
12	KBr+H ₂ SO ₄	None.	red		A drop or two of each.
13	Zn	Cu	"	HNO ₃	Also Al, Bi, Fe, Ni, Pb, Sn.
14	Na ₂ CO ₃ } B.B.C.C. }	"	"	"	No incrustation.



57. GROUP II, A.—Hg'', Pb, Bi, Cd, Cu.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	SOL.
1. Ppt. HgS, PbS, Bi₂S₃, CdS, CuS (v. As, Sn, Sb). Sat. sol. with H ₂ S gas, filter, test filtrate, wash residue until washings give no ppt. with a drop AgNO ₃ .	(1) HgS, PbS, Bi₂S₃, CdS, CuS	
2. Separate Hg from Pb, Bi, Cd, Cu. To (1) add little dil. HNO ₃ , boil a minute, decant, leave residue.	(2) HgS (S)	(a) Pb(NO₃)₂, Bi(NO₃)₃, Cd(NO₃)₂, Cu(NO₃)₂
3. Dis. HgS in aqua regia. To (2) add a few drops aqua regia, stir, warm if neces- sary.	(S)	(b) HgCl₂
4. Final test for Hg (v. Hg', Sn). Boil to expel all free Cl, add SnCl ₂ sol.	(3) HgCl, Hg	
5. Sep. Pb from Bi, Cd, Cu. Expel all HNO ₃ from (a), add little dil. H ₂ SO ₄ + C ₂ H ₅ OH, shake, let stand, filter, test fil.	(4) PbSO₄	(c) Bi(NO₃)₃, Cd(NO₃)₂, Cu(NO₃)₂
6. Sep. Bi from Cd, Cu. To (c) add AmOH, shake, let stand, filter.	(5) Bi(OH)₃	(d) (NH₄)₂CdO(AmNO₃)₂, (NH₄)₂CuO(AmNO₃)₂
7. Sep. Cd from Cu. To (d) add KCy sol. until any blue color disappears, then sat. (e) with H ₂ S.	(6) CdS	(e) (KCy)₂CdCy₂, (KCy)₂CuCy₂ (f) (KCy)₂CuCy₂
8. Final test for Cu. Acidify (f) with HCl.	(7) CuS	

Supplementary.—1. Acidulate the original sol. with HCl (not HNO₃, which, like other oxidizing agents, decomposes H₂S). Unless the sol. is acid, Co, Ni, Zn are liable to ppt. if present. If too acid, Cd, Pb, etc., will not ppt. If no ppt. falls, dil. the sol. 1. Be sure the sol. is sat. with H₂S; to ascertain this test the fil. 2. A black res. may not be HgS, but S with enclosed particles of PbS, Bi₂S₃, CuS. Hence confirm by SnCl₂. 5. Test a small part of the sol. for Pb at first. 6. Excess of AmOH must be used to ppt. all the Bi (which otherwise may appear in the final Cd test) and to dis. Cu(OH)₂ and Cd(OH)₂ at first formed. Bi may be confirmed by dis. ppt. in a few drops of HCl, evaporating free acid and adding to H₂O. 6. If the color is not blue on adding AmOH no appreciable Cu is present. Unless previously removed Pb will ppt. with AmOH. 7. The final Cd ppt. must be yellow. If not, some of the other metals have failed to ppt. at the right place, and will appear here.

As, Sn, Sb—Group II, B—are omitted here for brevity. They are ppd. by H₂S, and may be separated from the whole of Group II by dissolving in Am₂S_x (v. Exp. 61). If Group I metals were not removed by HCl, would they ppt. with Group II (test each with H₂S)?

58. ARSENIC, As^{'''}.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. As_2S_3 (v. Group II, A; Sn, Sb). Sat. sol. with H_2S , filter (test fl.), wash.	(1) As_2S_3	yellow	
2. As_2S_3 insol. in HCl (v. Sn, Sb). Cover (1) with HCl, boil a minute, filter, wash.	(2) As_2S_3	yellow	
3. Dis. As_2S_3 in Am_2S_x . To (2) add Am_2S_x , boil, filter if necessary.	(S)		(a) Am_2AsS_3
4. Re-ppt. As_2S_3 . Cautiously acidify (a) with HCl.	(3) As_2S_3 , (S)	yellow	

Supplementary. — The original sol. should be acidified with HCl. (a) Try a neutral sol. with H_2S , also (b) an alkaline. H_2S acts *very slowly* on As^v , but more rapidly when hot than when cold, ppg. $As_2S_3 + S$. Test (c) an acid, (d) a neutral, (e) an alkaline sol. of As salts with a sol. of a Cu salt. What 2 yellow ppts. formed by H_2S ? (f) Test the solubility of each in Am_2S_x .

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$AgNO_3$	Ag_3AsO_4	yellow	$\begin{cases} AmOH \\ \text{dil. HCl} \\ AmCl \end{cases}$	As^v (neutral) + $AgNO_3 = Ag_3AsO_4$ (red-brown).
2	H_2S	As_2S_3	$\begin{cases} \text{lemon-} \\ \text{yellow} \end{cases}$	$\begin{cases} Am_2CO_3 \\ Am_2S_x \\ NaOH \end{cases}$	Re-pptd. by HCl.
3	Am_2S	"	"	"	"
4	$CuSO_4$	$HCuAsO_3$	green	$\begin{cases} AmOH \\ \text{dil. acids} \end{cases}$	Scheele's green (Paris green).
5	$KMnO_4$				Decolorized.
6	$CuAc_2$	$\begin{cases} CuO(As_2O_3)_2 \\ CuAc_2 \end{cases}$	"	$\begin{cases} AmOH \\ \text{and acids} \end{cases}$	Schweinfurt green.
7	Cu	As	gray	aq. reg.	Paris green.
8	H (nascent)	AsH_3 (gas)			Heated with HCl (Reinsch's test).
9	$Na_2CO_3 + KCy$	As	gray	HCl	Burns with pale-white flame.
10	C (heated)	"	"	"	Deposits As on porcelain.
11	$\begin{cases} AmCl + AmOH \\ + MgSO_4 \end{cases}$	$AmMgAsO_4$	white	"	AsH_3 very poisonous (Marsh's test).
12	Am_2MoO_4	$AmAs(MoO_4)_3$	yellow	"	Sublimed if heated dry.
					Garlic odor.
					For As^v only.
					Composition uncertain (v. M_3PO_4).

59. TIN, Sn^{iv}.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. SnS (v. Group II, A; As, Sb). Sat. sol. with H ₂ S, filter, wash.	(1) SnS	chocolate	
2. Dis. SnS in HCl (v. As). To (1) add HCl, boil, filter if necessary.	(S)		(a) SnCl₂
3. Hg test for Sn . To (a) add HgCl ₂ sol.	(2) HgCl₂ , Hg	white gray	

Supplementary. — SnCl₂ sol. should be freshly prepared, and both Sn and HCl left in the sol. Otherwise SnCl₄ and Sn₂OCl₂ are formed. Sn^{iv} with H₂S gives yellow SnS₂, sol. in Am₂S_x, or Am₂CO₃. (a) Try to dis. Sn in HNO₃ (strong and dil.). Try to dis. part of the res. in (b) HCl, part in (c) aqua regia. What metals have no nitrates? Which of the following can exist in sol. together? (d) SnCl₂ and HgCl; (e) SnCl₄ and HgCl; (f) SnCl₄ and HgCl₂. (g) Change SnCl₂ to SnCl₄; (h) SnCl₄ to SnCl₂. Give proof of the change in both cases. (i) Sep. Sn from As. (j) Can SnCl₂ and AgNO₃ exist in sol. together? (k) SnCl₂ and PbCl₂?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Sn(OH)₂	white	NaOH	Ppt. from Sn ^{iv} is SnO(OH) ₂ , white.
2	NaOH	"	"	"	Boiling gives SnO. Boiling NaOH + H ₂ Tr gives Sn (black).
3	Am₂CO₃	"	"	"	Insol. in excess (v. Sb ^{'''}).
4	Na₂CO₃	"	"	"	" " " " " "
5	HgCl₂	HgCl + Hg	{white, gray		If dil. HgCl, if strong Hg.
6	H₂S	SnS	brown	{ NaOH Am₂S₂ HCl	{Normal Am ₂ S does not dis. SnS. If Sn ^{iv} is present, ppt. is SnS ₂ (yellow).
7	KI	SnI₂	yellow	HCl, NaOH	In neutral, concentr. sol.
8	Am₂Ox	SnOx	white	HCl	
9	HN₃PO₄	Sn₂(PO₄)₃	"	Acids	
10	KCy	Sn(OH)₂	"	HCl, NaOH	HCy (very poisonous) is evolved.
11	K₂FeCy₆	Sn₂FeCy₆	"		
12	HNO₃, Cl				Oxidizes Sn ^{iv} to Sn ^{iv} .
13	O or H₂O	Sn₂OCl₂	white	HCl	SnCl ₄ also formed and dissolved. Sn and HCl added retard action.
14	Zn	Sn	{gray, spongy	"	Also Al, Cd, Mg.
15	Na₂CO₃ } B.B.C.C. }	"			Use excess Na ₂ CO ₃ and little KCy.

60. ANTIMONY, Sb^{III}.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Sb₂S₃ (v. Group II, A; As, Sn). Sat. sol. with H ₂ S, filter, wash.	(1) Sb ₂ S ₃	orange	
2. Dis. Sb₂S₃ in HCl (v. As). To (1) add HCl, boil, filter if necessary.			(a) SbCl ₃
3. Inaction of HgCl₂ on SbCl₃ (v. Sn). Divide (a), to half add HgCl ₂ sol.			(b) SbCl ₃
4. Re-ppt. Sb₂S₃ . Dilute other half (a), add H ₂ S.	Sb ₂ S ₃	"	

Supplementary. — Sb₂S₃ will not ppt. from too acid or too alkaline sols., and only imperfectly from neutral. SbCl₃ is insol. in H₂O, reacting with it to form insol. SbOCl (which H₂S changes to Sb₂S₃). It should be acidulated with HCl. Try to dis. Sb in HNO₃. If not sol., test the res. (a) with HCl, (b) with aqua regia. (c) Add HgCl₂ sol. to SbCl₃ sol. Explain. (d) Apply the "spot test," i.e. Marsh's test (Exp. 44), to Sb. (e) Sep. Sb from Sn; (f) Sb from As. Would you be likely to find SbCl₃ in sol. with the first group metals? With a purely aqueous sol. of Group II, A?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Sb ₂ O ₃	white	{ Hot NaOH (ex.), HCl	Sol. should be slightly acid.
2	NaOH	"	"	" "	" " "
3	Am ₂ CO ₃	"	"	" "	" " "
4	Na ₂ CO ₃	"	"	{ HCl, hot Am ₂ CO ₃ , Acids	" " "
5	H ₂ O	SbOCl (var.)	"	{ Am ₂ Sx, NaOH, hot HCl	Part only ppts.
6	H ₂ S	Sb ₂ S ₃	orange	"	
7	Am ₂ S	"	"	"	If too acid or too alkaline, no ppt.
8	KI	no ppt.	yellow		Sb ^v ppts. I.
9	Am ₂ Ox	Sb(NH ₄) ₃ Ox ₃	white		Ppts. slowly.
10	KCy	uncertain	"		
11	K ₄ FeCy ₆	"	"		Insol. in acids.
12	Zn	Sb	black	aqua regia	Also Bi, Cu, Mg, Fe, Sn.
13	Na ₂ CO ₃ } B.B.C.C. }	"	"	aqua regia	{ Metallic, brittle, white incrust., green flame, white fumes (Sb ₂ O ₃).

61. GROUP II, B. — As, Sn, Sb.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	SOL.
1. Ppt. As_2S_3, SnS, Sb_2S_3 (v. Group II, A). Sat. sol. with H_2S , filter, wash.	(1) As_2S_3 , SnS , Sb_2S_3	
2. Sep. Sn and Sb from As. Warm (1) in e.d. some time with HCl, decant on filter.	(2) As_2S_3 (S)	(a) $SnCl_2$, $SbCl_3$
3. Dis. As_2S_3. To (2) add Am_2S_x , boil, filter if necessary.	(S)	(b) Am_4AsS_3
4. Final test for As. Cautiously acidify (b) with HCl.	(3) As_2S_3 (S)	
5. Final test for Sn. Divide (a), to half add $HgCl_2$ sol.	(4) $HgCl$, Hg .	
6. Final test for Sb. Dilute other half (a), add H_2S .	(5) Sb_2S_3	

Supplementary. — 1. If there is very much HCl in the sol., Sb and Sn may not ppt. To determine this, dilute a little of the sol., and test with H_2S . 2. The sol. should be warmed with HCl *in excess* some time, not boiled, or As will go into solution. As_2S_3 may be dis. by a sat. sol. of Am_2CO_3 (made without $AmOH$), warmed, and sep. from Sb and Sn; then ppt. As_2S_3 with HCl (cautiously). 3. If no appreciable res. is left in 2 except S, omit 3. 6. If Sb is present, an orange ppt. will appear first, followed later (if Sn is also there) by chocolate SnS. Metals of Group II, B, are sep. from those of Group II, A, by dis. the sulfids of the former in Am_2S_x (not Am_2S). A white ppt., on adding HCl is liable to be S. (a) Sep. $SbCl_3$ from $CuCl_2$; (b) $SnCl_2$ from $BiCl_3$.

62. IRON (Ic), Fe'''.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Fe(OH)₃ (v. Cr, Al). To sol. add AmCl sol., AmOH, warm, filter, wash res.	(1) Fe(OH)₃	{ red brown	(a) FeCl₃
2. Dis. Fe(OH)₃ in HCl (v. Cr, Al). To (1) in e.d. add dil. HCl, stir.			
3. Re-ppt. Fe(OH)₃ with NaOH (v. Cr, Al). To (a) add excess NaOH sol.	(2) Fe(OH)₃	{ red brown	

Supplementary. — To reduce Fe''' to Fe'' v. Exp. 47. To oxidize Fe'' to Fe''' v. Exp. 47. Test FeCl₃ sol. (Fe''') in t.t. with a few drops of (a) K₄FeCy₆, (b) K₃FeCy₆, (c) KSCy, (d) NaOH. (e) Test also FeSO₄ sol. (Fe'') with the same reagents, and tabulate results. Then state what will distinguish Fe'' from Fe'''. (f) Dis. a little Fe in dil. H₂SO₄, nearly evap., add H₂O, and then determine whether FeSO₄ or Fe₂(SO₄)₃ is found. (g) Dis. a little Fe in aqua regia, evap., dil., test as before. (h) Test also the product after dis. in HCl. (i) Sep. Fe''' from Cu''; (j) Fe'' from Bi'''. (It is better to oxidize Fe'' to Fe''' before separation.) (k) Can a sol. contain both FeCl₃ and HgNO₂? (l) FeSO₄ and Cu(NO₃)₂? (m) Make FePO₄. Will H₂S ppt. FeS? Fe₂S₃ is not formed in aqueous analysis.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Fe(OH)₃	{ red brown	Acids	Variable to Fe ₂ O ₂ (OH) ₂ .
2	NaOH	"	"	"	" " "
3	Am₂CO₃	"	"	"	" " "
4	Na₂CO₃	"	"	"	Traces Fe ₂ (CO ₃) ₃ .
5	HNaPO₄	FePO₄	white	M. acids	Variable to Fe ₂ O ₂ (OH) ₂ . Fe''' (except FeAc ₃) ppt. by this and NaAc (v. M ₂ PO ₄).
6	Am₂Ox	Fe₂Ox₃	"	Acids	
7	KCy	Fe(OH)₃	{ red brown	"	HCy formed (very poisonous).
8	K₄FeCy₆	Fe₃Fe₂Cy₁₂	blue	H₂SO₄	Prussian blue. NaOH + ppt. = Fe(OH) ₃ .
9	K₃FeCy₆				No action; distinguishes Fe''' from Fe''.
10	KSCy	FeCy₂S₂	{ blood- red		Color only, no ppt.
11	H₂S	S	white	Acids	Disting. Fe''' from Fe''.
12	Am₂S	FeS + S	black		Reduces Fe''' to Fe''.
13	{ Tannic acid and galls.	Fe''' tannate	"		First reduces Fe''' to Fe''.
14	NaAc	Fe₂Ac₂(OH)₂	red		Basis of writing ink.
15	{ SO ₂ , H ₂ S Zn, SnCl ₂				Reduce Fe''' to Fe''.



63. IRON, Fe^{''}.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Fe(OH) ₂	{ green black	{ AmCl (sl.), Acids	White, if pure. Oxidizes to Fe(OH) ₃ , red-brown.
2	NaOH	"	"	"	" " "
3	Am ₂ CO ₃	FeCO ₃	white	"	Oxidizes to Fe(OH) ₃ .
4	Na ₂ CO ₃	"	"	"	" " "
5	H ₂ S	FeS	black	"	With FeAc ₃ only a slight ppt.
6	Am ₂ S	"	"	"	Oxidizes to FeO(SO ₄) ₂ .
7	Am ₂ Ox	FeOx	{ yellow- white	M. acids	
8	HNa ₂ PO ₄	HFePO ₄	{ blue- white	Acids	Fe ₃ (PO ₄) ₂ also formed.
9	KCy	FeCy ₂	{ yellow- red	KCy (ex.)	
10	K ₂ FeCy ₆	K ₂ Fe ₂ Cy ₆	{ blue- white		Oxidizes in air to Prussian blue.
11	K ₂ FeCy ₆	Fe ₃ Fe ₂ Cy ₁₂	blue		Distinguishes Fe ^{''} from Fe ^{'''} .
12	KSCy	no effect			" " "
13	HNO ₃ , KClO ₃				
14	Cl, &c.	Fe ^{'''} (no ppt.)	red		Oxidizes Fe ^{''} to Fe ^{'''} .
15	{ Tannic acid + tincture galls	Fe ^{''} tannate	{ white to black		Oxidizes to Fe ^{'''} tannate (black ink).

Supplementary. — In the separation of Fe^{''} it is first oxidized to Fe^{'''}, and then tested as in Group III. To ascertain whether you have a ferrous (Fe^{''}) or a ferric (Fe^{'''}) salt, test the original sol. by the table below. (a) Prepare some Prussian blue; (b) Everitt's salt; (c) Turnbull's blue; (d) black ink.

TESTS FOR FERROUS AND FERRIC IRON.

RE-AGT.	Fe ^{''} .	Fe ^{'''} .
K ₂ FeCy ₆	K ₂ FeFeCy ₆ (bluish white). Potassium ferrous-ferro-cyanid or Everitt's salt.	Fe ₃ Fe ₂ Cy ₁₂ (deep-blue). Ferric-ferro-cyanid or Prussian blue.
K ₂ FeCy ₆	Fe ₃ Fe ₂ Cy ₁₂ (dark-blue). Ferrous-ferri-cyanid or Turnbull's blue.	FeFeCy ₃ (green or brown color only). Ferric-ferri-cyanid.
KSCy	No effect.	Fe(SCy) ₃ (blood-red color only). Ferric-sulpho-cyanid.
KOH	Fe(OH) ₂ (white to dirty green). Ferrous hydroxid.	Fe(OH) ₃ (red-brown). Ferric hydroxid.



64. ALUMINUM, Al^{'''}.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Al(OH)₃ (v. Fe, Cr). To sol. add AmCl sol., AmOH, boil, filter.	(1) Al(OH) ₃	white	
2. Dis. Al(OH)₃ in HCl (v. Fe, Cr). To (1) add dil. HCl, stir.			(a) AlCl ₃
3. Dis. Al(OH)₃ in NaOH (v. Fe, Cr, Zn). To (a) add excess. strong NaOH sol., shake.			(b) Na ₂ Al ₂ O ₄
4. Al(OH)₃ insol. in AmOH. Acidify (b) with HCl, add AmOH.	(2) Al(OH) ₃	"	

Supplementary. — 3. NaOH sol. must be in excess, and strong enough to dis. the Al(OH)₃ first formed. (a) Sep. Fe from Al. (b) Test action of limited NaOH sol. on Al. (c) Is Al₂S₃ formed in aqueous analysis [try H₂S and Am₂S; a ppt. is Al(OH)₃] ? (d) Test Al^{'''} and AmCl sol. with NaOH sol. (e) Now ppt. Al(OH)₃ with AmCl and NaOH, and try to dis. it in excess. (f) Sep. Cu and Al; (g) Bi and Al. (h) Obtain AlCl₃ from several cpds. of Al, in two or three different ways. (i) Obtain alum crystals by mixing sols. of sulfates of Al and K (Exp. 5). Try to dis. Al in (j) HCl, (k) HNO₃.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Al(OH) ₃	{ gray white	NaOH, acids	{ NaOH (ex.) forms Na ₂ Al ₂ O ₄ , not re- ppd. by boiling (v. Zn).
2	NaOH	"	"	"	{ NaOH (ex.) forms Na ₂ Al ₂ O ₄ ; AmCl re-ppts. it.
3	Am ₂ CO ₃	"	"	Na ₂ CO ₃	Liberates CO ₂ .
4	Na ₂ CO ₃	"	"	Na ₂ CO ₃ (ex.)	" "
5	Am ₂ S	"	white	Acids	H ₂ S evolved.
6	K ₄ FeCy ₆	uncertain	"	"	
7	HN ₂ PO ₄	AlPO ₄	"	NaOH, HCl	
8	Na ₂ S ₂ O ₃	Al(OH) ₃ + S	"	Acids	SO ₂ liberated.
9	{ Na ₂ B ₄ O ₇ (bead) B.B.C.C. + Co(NO ₃) ₂		blue		{ First heat : infus. Add a drop of Co(NO ₃) ₂ sol., heat : blue.

65. CHROMIUM (1c), Cr^{'''}.

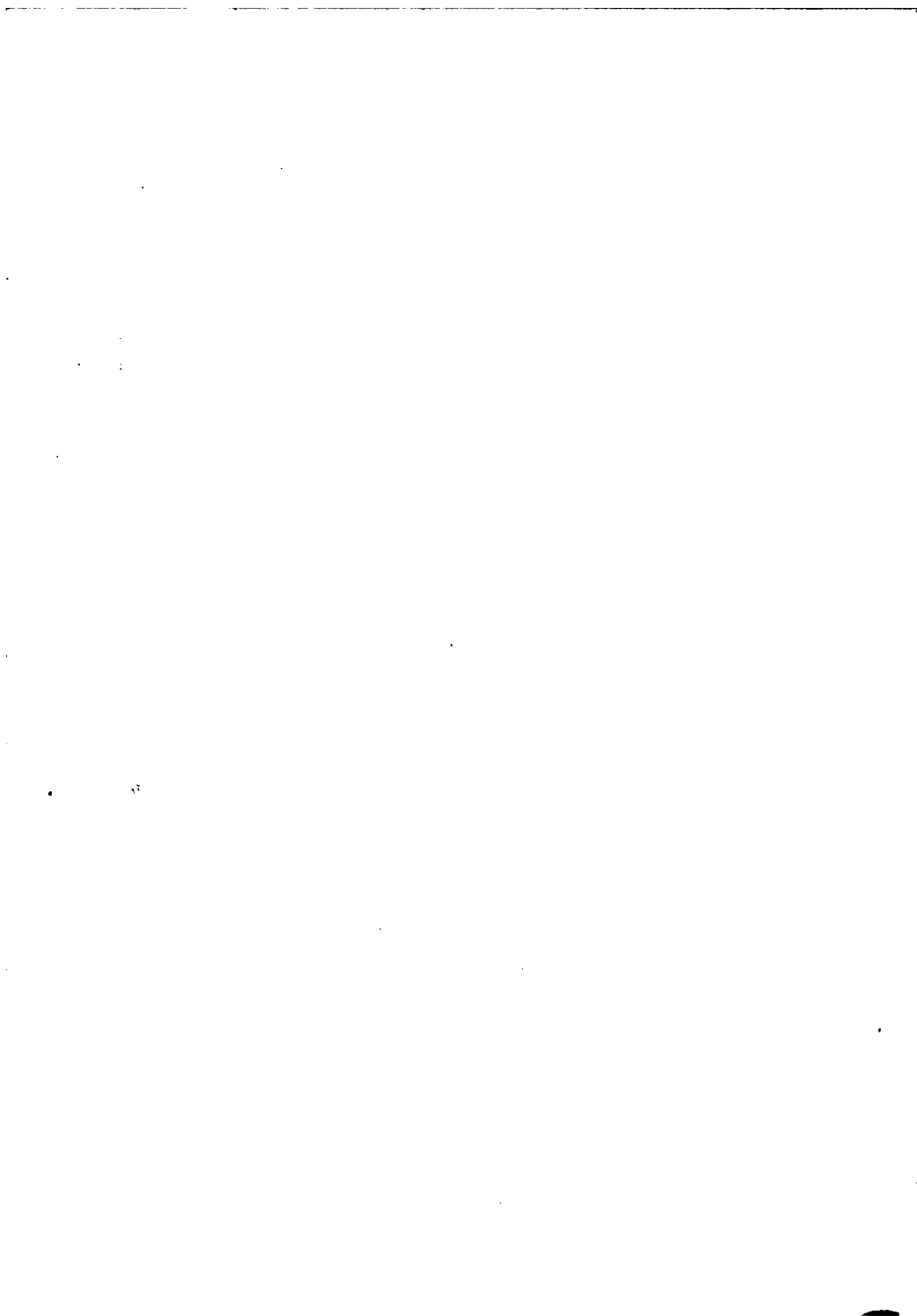
ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Cr(OH)₃ (v. Fe, Al). To sol. add AmCl sol., AmOH; warm.	(1) Cr(OH) ₃	green	
2. Dis. Cr(OH)₃ in HCl (v. Fe, Al). To (1) add dil. HCl, stir, filter if necessary.			(a) CrCl ₃
3. Oxidize Cr^{'''} to Cr^{vi} . Evap. (a) almost to dryness, then add 1 or 2 crystals KClO ₃ , and evap. to dryness; add H ₂ O, filter if necessary.			(b) K ₂ Cr ₂ O ₇
4. Action of NaOH on K₂Cr₂O₇ . To (b) add NaOH sol.			(c) K ₂ CrO ₄
5. Ppt. PbCrO₄ . Acidify (c) with HAc, add Pb(NO ₃) ₂ sol.	(2) PbCrO ₄	yellow	

Supplementary. — 1. Cr(OH)₃ may dis. in cold water, but re-ppts. on boiling. 3. Cr^{'''} must be oxidized to Cr^{vi}, or it will ppt. with NaOH sol. (a) Sep. Cr^{'''} from Al^{'''}. (b) To K₂Cr₂O₇ sol. add successive small portions of AmOH, shaking each time, till the color becomes yellow. Alkalies reduce red dichromates to yellow chromates; acids have the reverse effect. (c) Slowly acidify the chromate with HCl. (d) Will Cr(OH)₃ ppt. from K₂Cr₂O₇ sol. ? (e) Reduce Cr^{vi} to Cr^{'''}. (f) Sep. Cr^{'''} and Fe^{'''}; (g) Cr^{'''} and Cd. (h) Make Cr₂(SO₄)₃ from K₂Cr₂O₇. (i) Make Cr(NO₃)₃.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Cr(OH) ₃	{ blue- green	{ NaOH(ex.) { Acids	Re-ppt. by hot AmCl or by boiling.
2	NaOH	"	"	NaOH (ex.)	" " " "
3	Am ₂ CO ₃	"	"	Na ₂ CO ₃ (ex.)	" " " "
4	Na ₂ CO ₃	"	"	"	" " " "
5	H ₂ S	Cr ₂ O ₃ CrO ₄			CO ₂ formed. Slight ppt. Reduces Cr ^{vi} to Cr ^{'''} in presence of HCl.
6	Am ₂ S	Cr(OH) ₃	"	Acids	Forms slowly if dilute; H ₂ S liberated.
7	HNa ₂ PO ₄	CrPO ₄	green	M. acids	
8	H ₂ SO ₄ +H ₂ O ₂	undeterm.	blue	(C ₂ H ₅) ₂ O	Blue liquid rises to surface with Cr ^{vi} only.
9	KCy	Cr(OH) ₃	{ blue- green	NaOH	HCy liberated.
10	KClO ₃ , Cl, &c.				Cr ^{'''} oxidized to Cr ^{vi} (yellow-red) with heat.
11	Na ₂ CO ₃ +KClO ₃	{ Na ₂ CrO ₄ { K ₂ CrO ₄	yellow	H ₂ O	Fused on Pt foil.
12	Na ₂ CO ₃ (bead)		green		V. Table G.



66. GROUP III.—Fe, Al, Cr.

SEPARATION.

DIRECTIONS.	PPT.	SOL.
1. Ppt. $\text{Fe}(\text{OH})_3$, $\text{Al}(\text{OH})_3$, $\text{Cr}(\text{OH})_3$. To sol. add AmCl sol., AmOH, boil a minute, filter, wash. 2. Dis. $\text{Fe}(\text{OH})_3$, $\text{Al}(\text{OH})_3$, $\text{Cr}(\text{OH})_3$ in HNO_3. To (1) add dil. HNO_3. 3. Oxidise $\text{Cr}(\text{NO}_3)_3$ to $\text{K}_2\text{Cr}_2\text{O}_7$. Evap. (a) to dryness; when almost evap. add 1 or 2 small crystals KClO_3. When evap. dis. in H_2O; decant on filter and add to res. a few drops HNO_3; pour on same filter. 4. Sep. Fe from Al and Cr. To (b) add excess strong NaOH sol., shake, filter. 5. Sep. Al from Cr. Acidify (c) with HCl, add AmOH, filter. 6. Final test for Cr. Partly evap. (d), dil., acidify with HAc, add $\text{Pb}(\text{NO}_3)_2$ sol.	(1) $\left\{ \begin{array}{l} \text{Fe}(\text{OH})_3, \text{Al}(\text{OH})_3, \\ \text{Cr}(\text{OH})_3 \end{array} \right.$ (2) $\text{Fe}(\text{OH})_3$ (3) $\text{Al}(\text{OH})_3$ (4) PbCrO_4	(a) $\left\{ \begin{array}{l} \text{Fe}(\text{NO}_3)_3, \text{Al}(\text{NO}_3)_3, \\ \text{Cr}(\text{NO}_3)_3 \end{array} \right.$ (b) $\left\{ \begin{array}{l} \text{Fe}(\text{NO}_3)_3, \text{Al}(\text{NO}_3)_3, \\ \text{K}_2\text{Cr}_2\text{O}_7 \end{array} \right.$ (c) $\text{Na}_2\text{Al}_2\text{O}_4, \text{K}_2\text{CrO}_4$ (d) K_2CrO_4

Supplementary. — 1. AmCl prevents pptn. by AmOH of Mg, Mn, Zn, Co, Ni (Fe'' partially), aids pptn. of Al, and does not affect Fe''' and Cr. Considerable AmCl is needed. AmOH at first pptn. Co, Ni, Zn, if present, all of which are sol. in excess. If only one of these Fe'' , Al, Cr, is present, the color determines which. $\text{Cr}(\text{OH})_3$ dis. in cold H_2O , but is re-pptd. on boiling. Fe'' should be oxidized to Fe''' by boiling with a few drops of HNO_3 . H_2S must all be removed by boiling before adding AmOH , to prevent formation of Am_2S and pptn. of Co, Ni, Mn, Zn. Cr^{vi} is reduced by H_2S to Cr''' , and hence pptd. here. 3. Cr''' must all be oxidized to Cr^{vi} or it will ppt. with Fe. 4. Fe should be tested in the original sol. for Fe'' or Fe''' by K_4FeCy_6 , K_3FeCy_6 , KSCy . 5. NaOH dis. some SiO_2 from the containing bottles, and there may be a ppt. of H_4SiO_4 , similar to $\text{Al}(\text{OH})_3$, small in quantity and sinking sooner than $\text{Al}(\text{OH})_3$. 6. A white ppt. of PbCl_2 will always appear if no Cr is present. The yellow color alone indicates Cr.

67. COBALT, Co⁺⁺.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. CoS (v. Ni, Mn, Zn). To sol. add AmCl sol., Am ₂ S, shake, warm, filter, wash res. with hot H ₂ O, adding to it a few drops Am ₂ S.	(1) CoS	black	
2. CoS insol. in HCl (v. Mn, Zn). To (1) add dil. HCl, stir, decant.	(2) CoS	"	
3. Dis. CoS in aqua regia (v. Ni). To (2) add a few drops of aqua reg., stir, filter, evap. acid, dil.	(3)		(a) CoCl ₂
4. Ppt. K₂Co₂O(NO₂)₁₀ . To (a) add HAC, KNO ₃ sol.	K ₂ Co ₂ O(NO ₂) ₁₀ (3)	yellow	

Supplementary. — 1. Am₂S (colorless) must be used, not Am₂S_x (yellow). 2. CoS is sol. in strong, hot HCl, and slightly in cold, as is NiS. 3. K₂CoO(NO₂)₁₀ is broken up by alkalis, or HCl, but not by HC₂H₃O₂. 1. CoS and NiS are liable to oxidize to the soluble sulfates if exposed long to the air, hence they must be filtered and washed at once. 4. Some ppt. may occur at once in 4, but to be sure all the Co is thrown down 24 hours is needed, and enough KNO₃ must be used. What sulfid in Group II was sol. in aqua regia only? Why is not CoS pptd. by H₂S with Group II? (a) To Co salts add H₂S, then AmOH. How is Am₂S made? (b) Make a borax bead by fusing with the blow-pipe a little Na₂B₄O₇ in the loop of a Pt. wire until it becomes clear. Dip this bead into a very weak sol. of CoCl₂ and fuse again. The blue color — if the sol. was not too strong — is very characteristic of Co. (c) Can AgNO₃ and CoCl₂ exist in sol. together? Sep. (d) Co and Cd; (e) Co and Cr.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Co(OH) ₂	red	{ AmOH (ex.), AmCl, &c.	{ Blue bas. ppt. first formed. On stand. forms Co(OH) ₃ . Oxidizes to Co(OH) ₂ .
2	NaOH	"	"	"	Insol. in NaOH (ex.).
3	Am ₂ CO ₃	Co ₂ OCO ₃	"	Am ₂ CO ₃ (ex.)	Violet or blue by heating.
4	Na ₂ CO ₃	"	"	"	Insol. in excess Na ₂ CO ₃ .
5	Am ₂ S	CoS	black	HNO ₃ , aq. reg.	Oxid. to CoSO ₄ , which is sol.
6	KNO ₃	K ₂ Co ₂ O(NO ₂) ₁₀	yellow	HCl	Ppts. only in pres. of HAC.
7	KCy	CoCy	br.-wh.	KCy (ex.)	Dist. from Ni by hot HCl.
8	K ₂ FeCy ₄	Co ₂ FeCy ₄			Grayish green.
9	K ₂ FeCy ₄	Co ₂ Fe ₂ Cy ₁₂	{ brown- red		{ In absence of Mn ⁺⁺ , or Ni, AmCl + AmOH + K ₂ FeCy ₄ + Co ⁺⁺ = blood-red color.
10	HNH ₂ PO ₄	HCoPO ₄	red	AmOH, acids	Dehydrated.
11	Heat (on paper)		blue		Blue bead in either flame.
12	Na ₂ B ₄ O ₇ (bead)		"		Oxidizes Co ⁺⁺ to Co ⁺⁺⁺ .
13	Cl, PbO ₂ (warm)		white		Also Cd, Mg.
14	Zn	Co	"	HCl	
15	Na ₂ CO ₃ } B.B.C.C. }	"	"	"	Magnetic.

68. NICKEL, Ni".

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. NiS (v. Co, Mn, Zn). To sol. add AmCl, Am ₂ S, warm, filter rapidly, wash res. with hot H ₂ O and a few drops of Am ₂ S.	(1) NiS	black	
2. NiS insol. in HCl (v. Mn, Zn). To (1) add little dil. HCl, stir and decant.	(2) NiS	"	
3. Dis. NiS in aqua regia (v. Co). To (2) add at once a few drops of aqua regia, stir, filter, evap. acid, and dilute.	(3)		(a) NiCl ₂
4. Inaction of KNO ₃ on NiCl and HAc. To (a) add little HAc, KNO ₃ sol.; leave 24 hours.			(b) NiCl ₂
5. Ppt. Ni(OH) ₂ . To (b) add <i>excess strong</i> NaOH sol.; boil if necessary.	(3) Ni(OH) ₂	{ apple-green	

Supplementary. — 1. Ni has not been wholly removed if the fil. is brown or has black particles in it. In that case acidify the fil. with HAc, boil, filter, and test for Ni. 3. In using aqua regia the smallest quantity (usually a few drops) that will suffice to dis. the substance must be employed. The sol. may afterwards be diluted. Note the color of Ni salts. Sep. (a) Ni and Co; (b) Ni and Fe; (c) Ni and Cu; (d) Ni, Cu, Al; (e) Ni, Bi, Sb. (f) Test Ni with borax bead (v. Co and Table G).

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Ni(OH) ₂	pale green	{ AmOH, AmCl, &c.	Sol. NaOH re-ppts. slowly (violet-blue).
2	NaOH	"	"	"	Insol. in NaOH (ex.). Unchanged in air.
3	Am ₂ CO ₃	"	green	Am ₂ CO ₃ (ex.)	Sol. has blue-green color.
4	Na ₂ CO ₃	"	"	Na ₂ CO ₃ (ex.)	" " " "
5	H ₂ S	NiS	black	HNO ₃ , aq. reg.	From neutral or alk. sol., not acid.
6	Am ₂ S	"	"	"	Sol. (sl.) in Am ₂ S (ex.).
7	K ₂ FeCy ₆	Ni ₂ FeCy ₆	green-white	AmOH	
8	K ₂ FeCy ₆	Ni ₂ FeCy ₆	green-yel.		AmCl + AmOH + K ₂ FeCy ₆ + Ni", boiled = red ppt.
9	HNa ₂ PO ₄	Ni ₂ (PO ₄) ₃	green-white		
10	KCy	NiCy ₂	yel.-green	KCy (ex.)	Dist. from Co by HCl.
11	M ₂ Ox	NiOx	green		Leave 24 hours.
12	Na ₂ B ₄ O ₇ (bead)				(V. Table G.) Co" obscures test.
13	Cl, Br, &c.				Oxidizes Ni" to Ni".
14	H ₂ S, SO ₂ , &c.				Reduces Ni" to Ni".
15	Zn	Ni	white		Also Cd, Sn.
16	{ Na ₂ CO ₃ B.E.C.C. }	"	"	HNO ₃	Magnetic powder.

69. MANGANESE (ous), Mn^{II} .

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. MnS (v. Co, Ni, Zn). To sol. add $AmCl$ sol., Am_2S , warm, filter, wash in hot H_2O and Am_2S .	(1) MnS	salmon	
2. Dis. MnS in HCl (v. Co, Ni). To (1) add dil. HCl , stir, filter, boil to expel all H_2S , NH_3 , &c. (test a little with $PbAc_2$).	(5)		(a) $MnCl_2$
3. Ppt. $Mn(OH)_2$ (v. Zn). To (a) add excess strong $NaOH$ sol., warm.	(2) $Mn(OH)_2$ $Mn_2O_3(OH)_2$	white brown	

Supplementary. — 3. $Mn(OH)_2$ will not ppt. with $NaOH$ if $AmCl$ and $AmOH$ are present. $Mn(OH)_2$ when pure is white, but it rapidly oxidizes to brown $Mn_2O_3(OH)_2$ (variable). This should further be tested by fusing it with a mixture of Na_2CO_3 and KNO_3 , when bright green K_2MnO_4 and Na_2MnO_4 are formed. (a) See whether $Mn(OH)_2$ or MnS forms in preference to the other. Will these exist together in sol.: (b) $MnCl_2 + ZnSO_4$? (c) $MnSO_4 + Cu(NO_3)_2$? (d) $MnCl_2 + K_2CrO_4$? Sep. (e) Mn and Ni ; (f) Mn and As ; (g) Mn , Cu , Cr ; (h) Pb , Sr , Mn .

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$AmOH$	$Mn(OH)_2$	white	$AmCl$, &c.	Quickly oxidizes to brown $Mn_2O_3(OH)_2$; insoluble in $AmCl$.
2	$NaOH$	"	"	"	" " " "
3	Am_2CO_3	$MnCO_3$	"	"	" " " "
4	Na_2CO_3	"	"	"	" " " "
5	H_2S	MnS	pink	HCl , HAc	MnS ppts. from $MnAc_2$ (unless HAc is present). Not otherwise.
6	Am_2S	"	"	"	
7	K_2FeCy_6	Mn_2FeCy_6	white	HCl	
8	K_3FeCy_6	$Mn_2Fe_3Cy_{12}$	brown		Insol. in acids.
9	HNa_2PO_4	$Mn_2(PO_4)_3$	white	Dil. acids	From Am_2MnCl_4 , etc., forms $AmMnPO_4$.
10	KCy	$MnCy_2$	"	KCy (ex.)	Darkens in air.
11	$MnOx$	$MnOx$	"	Acids	
12	$Na_2B_4O_7$ (bead)		amethyst		In o. f. In r. f. colorless (v. Table G).
13	$Na_2CO_3 + KNO_3$ } ignited on Pt foil	K_2MnO_4 } Na_2MnO_4 }	green		Na_2CO_3 bead (o. f.), same green color.
14	Cl , Br , &c.				Oxidizes to Mn^{III} .
15	(H_2S) , SO_2 , &c.				Reduces Mn^{III} to Mn^{II} , ppts. S.
16	Zn				Reduces Mn^{III} to Mn^{II} when rightly acidulated.
17	$HNO_3 + PbO_2$ (boil)	$HMnO_4$ (sol.)	red		Seen on settling of sediment.

70. ZINC, Zn".

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. ZnS (v. Co, Ni, Mn). To sol. add AmCl , Am_2S , warm, filter, wash with hot H_2O and a few drops of Am_2S .	(1) ZnS	white	
2. Dis. ZnS in HCl (v. Co, Ni). To (1) add dil. HCl , stir, filter.	(8)		(a) ZnCl₂
3. Zn(OH)₂ sol. in excess NaOH (v. Mn). To (a) add excess strong NaOH sol.			(b) Na_2ZnO_2
4. Re-ppt. ZnS . Acidify (b) with HAc , add Am_2S .	(2) ZnS	"	

Supplementary. — 1. ZnS is the only white sulfid, but it must not be confounded with a white ppt. of S. 3. Zn(OH)_2 is not sol. in dil. sol. of NaOH , especially if boiled. 4. ZnS is ppd. by H_2S if the sol. is acidified with HAc . Zn ppts. these metals from sols. of their salts: Pb, Ag, Hg, Bi, Cd, Cu, As, Sn, Sb, Co, Ni, Fe. State color of each sulfid in Groups II and IV (tabulate). What hydroxids are sol. in excess of NaOH ? Sep. (a) Zn and Al; (b) Zn and Co; (c) Zn and Mn; (d) Pb, Fe, Zn.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	Zn(OH)₂	{ gel. white	AmOH (ex.)	Forms Am_2ZnO_2 . Boiling re-ppts.
2	NaOH	"	"	NaOH (ex.)	All Zn salts are sol. in NaOH , except ZnS.
3	Am_2CO_3	$\text{Zn}_2(\text{OH})_2(\text{CO}_3)_2$	"	AmOH	
4	Na_2CO_3	"	"	"	
5	H_2S	ZnS	white		From neutral sol. only, and in part only.
6	Am_2S	"	"	HCl	Insol. in HAc (v. Mn").
7	K_2FeCy_6	Zn_2FeCy_6	"		
8	K_2FeCy_6	$\text{Zn}_2\text{Fe}_2\text{Cy}_{12}$	yellow		
9	KCy	ZnCy₂	white	KCy (ex.)	
10	$\text{Na}_2\text{B}_4\text{O}_7$ (bead)				Hot, yellow; cold, white.
11	Na_2CO_3 } B.B.C.C. }	ZnO, Zn	yellow		{ Asincrustation. On cooling becomes white. $\text{Co(NO}_3)_2$ makes green color on heating again.

71. GROUP IV.—Co, Ni, Mn, Zn.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	SOL.
1. Ppt. CoS, NiS, MnS, ZnS. To sol. add AmCl, Am ₂ S, shake, warm (not boil), filter rapidly. Pour on res. a few drops Am ₂ S, then wash with hot H ₂ O.	(1) CoS, NiS, MnS, ZnS	
2. Sep. Co, Ni from Mn, Zn. To (1) in e.d. add dil. HCl, stir well, filter and wash.	(2) CoS, NiS	(a) MnCl₂, ZnCl₂
3. Dis. CoS and NiS. To (2) add at once <i>very little aqua regia</i> . Evap. acid, dil., add HAc.	(3)	(b) CoCl₂, NiCl₂
4. Sep. Co from Ni. To (b) add excess strong KNO ₃ sol., leave 24 hours, filter.	(3) K₂Co₂O(NO₃)₁₀	(c) NiCl₂
5. Final test for Ni. To (c) add <i>excess strong</i> NaOH sol., boil.	(4) Ni(OH)₂	
6. To separate Mn from Zn. Partly evap. (a) to concentrate the sol. and expel all NH ₃ , acidify with HAc, add excess strong NaOH sol., shake, let stand, filter.	(5) Mn(OH)₂, Mn₂O₃(OH)₂	(d) Na₂ZnO₂
7. Final test for Zn. Acidify (d) with HAc, add Am ₂ S.	(6) ZnS	

Supplementary. — 1. Am₂S (colorless), not Am₂S_x (yellow), must be used. CoS, NiS, etc., oxidize to sulfates in air. Hence filter rapidly with H₂O having a few drops of Am₂S. Group II metals, if not all removed, may ppt. here. 2. CoS, NiS are dis. by strong hot HCl, and slightly by cold. 6. ZnS, MnS will ppt. on adding NaOH if any H₂S is present. Mn will not ppt. with NaOH if AmCl and AmOH are present. Zn(OH)₂ is sol. in excess of strong cold NaOH sol. only. Mn should be tested for by fusing with Na₂CO₃ and KNO₃. (a) What members of Group III will Am₂S ppt. ? (b) of Group II ? (c) Group I ?

72. BARIUM, Ba⁺⁺.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Inaction of AmCl, AmOH on Ba salts (v. Mg). To sol. add AmCl sol., AmOH.			(a) BaCl ₂
2. Ppt. BaCO ₃ (v. Sr, Ca, Mg). To (a) add Am ₂ CO ₃ sol., warm, filter, wash.	(1) BaCO ₃	white	
3. Dis. BaCO ₃ in HAc (v. Sr, Ca). To (1) add little HAc.			(b) BaAc ₂
4. Action of K ₂ Cr ₂ O ₇ on BaAc ₂ (v. Sr, Ca). To (b) add K ₂ Cr ₂ O ₇ sol.	(2) BaCrO ₄	yellow	

Supplementary. — Has AmOH any effect on sol. salts of Ba? (a) Sep. Ba and Mn; (b) Ba and Fe⁺⁺⁺; (c) Ba and Bi; (d) Ba and Hg⁺⁺; (e) Ba and Hg⁺. (f) What numbers of Group IV will Am₂CO₃ ppt.? (g) Group III? (h) Group II? (i) Group I? What Ba salt is insol. in HCl (v. Exp. 100)? For what test is Ba(OH)₂ used? BaCO₃ occurs free in nature. How can other Ba salts be made from it? (g) Make several. (h) Test the Ba flame by dipping a Pt. wire (or a splinter) into BaCl₂ and holding it in the edge of a Bunsen flame.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	NaOH	Ba(OH) ₂	white	20 H ₂ O, Acids	Must be very conc. sol.
2	Am ₂ CO ₃	BaCO ₃	"	Acids	Slightly sol. in AmCl, aided by AmOH and heat.
3	Na ₂ CO ₃	"	"	"	" " " " "
4	HNa ₂ PO ₄	HBaPO ₄	"	"	Also AmCl (sl.). Must be neutral or alkaline.
5	M ₂ SO ₄	BaSO ₄	"	350,000 H ₂ O	One of the most insol. of salts.
6	K ₂ CrO ₄	BaCrO ₄	yellow	{ HAc (sl.), HCl (warm)	Re-ppd. by AmOH.
7	K ₂ Cr ₂ O ₇	"	"	"	" " "
8	H ₂ SiF ₆	BaSiF ₆	white	HCl, HNO ₃	C ₂ H ₅ OH aids ppn., also stirring, standing and boiling. Sr not ppd. by H ₂ SiF ₆ .
9	Am ₂ Ox	BaOx	white	Acids	From conc. sols.
10	Flame test		{ yellow-green		Vis. through indigo sol.; blue-green through green glass.

73. STRONTIUM, Sr⁺⁺.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COL.	SOL.
1. Inaction of AmCl and AmOH on Sr salts (v. Mg). To sol. add AmCl sol., AmOH.			(a) SrCl ₂
2. Ppt. SrCO ₃ (v. Mg, Ba, Ca). To sol. add Am ₂ CO ₃ sol., warm, filter, wash.	(1) SrCO ₃	white	
3. Dis. SrCO ₃ in HAc (v. Ba, Ca). Pour on (1) a little HAc.			(b) SrAc ₂
4. Inaction of K ₂ Cr ₂ O ₇ on SrAc ₂ (v. Ba). To (b) add little K ₂ Cr ₂ O ₇ sol.			(c) SrAc ₂
5. Ppt. SrSO ₄ with Am ₂ SO ₄ . To (c) add Am ₂ SO ₄ sol., shake well, let stand, filter, test filtrate.	(2) SrSO ₄	"	

Supplementary. — (a) Test the Sr flame by dipping a Pt. wire (or a splinter) into a Sr salt, and holding it in the edge of a Bunsen flame. Sep.: (b) Sr and Ba; (c) Group IV and Sr; (d) Group III and Sr; (e) Group II and Sr; (f) Group I and Sr. (g) If HCl were used instead of HAc (in 3), would the subsequent reaction take place just as well? (h) See whether you can ascertain which is more insol., SrSO₄ or BaSO₄.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	NaOH	Sr(OH) ₂	white	{ Acids 60H ₂ O	From conc. sol. "
2	Am ₂ CO ₃	SrCO ₃	"	Acids	From neutral or alkaline sol.
3	Na ₂ CO ₃	"	"	"	" " " " "
4	HNa ₂ PO ₄	HSrPO ₄	"	M. acids	Partly sol. in AmCl.
5	M ₂ SO ₄	SrSO ₄	"	{ 500HCl, 7000H ₂ O	Let it stand some time.
6	Am ₂ Ox	SrOx	"	{ HCl, HNO ₃ , AmCl	Slightly sol. in HAc.
7	K ₂ CrO ₄	SrCrO ₄	yellow	Acids	From conc. sol.
8	Flame test		crimson		Best with SrCl ₂ .

74. CALCIUM, Ca⁺⁺.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COL.	SOL.
1. Inaction of AmCl and AmOH on Ca salts (v. Mg). To sol. add AmCl sol., AmOH.	(1) CaCO ₃	white	(a) CaCl ₂
2. Ppt. CaCO₃ (v. Mg). To (a) add Am ₂ CO ₃ sol., warm, filter, wash.			
3. Dis. CaCO₃ in HAc (v. Ba, Sr). Pour on (1) a little HAc.			(b) CaAc ₂
4. Inaction of K₂Cr₂O₇ on CaAc₂ (v. Ba, Sr). To (b) add K ₂ Cr ₂ O ₇ sol.			(c) CaAc ₂
5. Action of Am₂SO₄ on CaAc₂ (v. Sr). To (c) add a little Am ₂ SO ₄ sol., very dil.			(d) CaAc ₂
6. Ppt. Ca with Am₂Ox. To (d) add AmOH and Am ₂ Ox sol.	(2) CaOx	"	

Supplementary. — Sep. (a) Ca and Ba; (b) Ca and Sr; (c) Ca and Pb; (d) Ca, Al, and Bi. CaCO₃ is the most abundant source of Ca salts. (e) Make several Ca salts from it. (f) Test CaCl₂ with a *strong* sol. of Am₂SO₄, and compare with SrCl₂. This will show why *very dil.* Am₂SO₄ must be used to sep. Sr and Ca. (g) Test the Ca flame, as in the case of Sr, and compare the two. (h) See whether CaSO₄ or SrSO₄ is more sol.; (i) BaSO₄ or CaSO₄.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	NaOH	Ca(OH) ₂	white	{ 700H ₂ O, AmOH Acids	Solubility decreased by heat. Conc. sol. only.
2	Am ₂ CO ₃	CaCO ₃	"		Slightly sol. with AmCl. Neutral or alkaline sol.
3	Na ₂ CO ₃	"	"	"	" " " " "
4	HNa ₂ PO ₄	HCaPO ₄	"	"	"
5	M ₂ SO ₄	CaSO ₄	"	{ H ₂ O (sl.), Acids (sl.), Am ₂ SO ₄	With dil. sol. use C ₂ H ₅ OH.
6	Am ₂ Ox	CaOx	"	M. acids	Insol. in HAc, H ₂ Ox. AmOH aids pptn.

75. MAGNESIUM, Mg'.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COL.	SOL.
1. Prevent ppt. of $Mg(OH)_2$ and $MgCO_3$ (v. Ba, Sr, Ca). To sol. add AmCl sol., AmOH.			(a) $(AmCl)_2MgCl_2$
2. Inaction of Am_2CO_3 on $(AmCl)_2MgCl_2$ (v. Ba, Sr, Ca). To (a) add Am_2CO_3 sol.			(b) $(AmCl)_2MgCl_2$
3. Ppt. $AmMgPO_4$. To (b) add HNa_2PO_4 .	(1) $AmMgPO_4$	white	

Supplementary. — Unless enough AmCl sol. is present, AmOH ppts. half of the Mg as $Mg(OH)_2$. $AmMgPO_4$ will not readily ppt. unless AmOH is present. (a) Verify the above statements. To ppt. $AmMgPO_4$ from very dil. sols., warm gently, stir with a glass rod, and let the sol. stand in a warm place some hours. (b) Verify with dil. sol. (c) Test action of Am_2CO_3 sol. on $MgCl_2$ sol. Does any previous group re-agent ppt. Mg? If so, how may ppt. be prevented? (d) Sep. Mg and Al; (e) Mg and Fe''' ; (f) Mg and Ba; (g) Mg and Cu.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AmOH	$Mg(OH)_2$	white	$\{ AmCl,$ $\{ 600H_2O$	Only half is ppd., rest is sol. as $Am_2Mg(SO_4)_2$.
2	NaOH	"	"	$\{ Acids,$ $\{ AmCl$	
3	Na_2CO_3	$Mg_2(CO_3)_2(OH)_2$	"	AmCl	Var. to $Mg_3(CO_3)_4(OH)_2$. CO_2 liberated.
4	Am_2CO_3	$Am_2Mg(CO_3)_2$	"	Dil. HCl	Variable with strength of sol.
5	HNa_2PO_4	$HMgPO_4$	"		In conc. sol. only.
6	HNa_2AsO_4	"	"		Action is like HNa_2PO_4 .
7	$\{ AmCl + AmOH$ $\{ + HNa_2PO_4$	$AmMgPO_4$	$\{ white$ $\{ cryst.$	$\{ Acids,$ $\{ 15,000H_2O$	
8	B.B.C.C.		pink		Heat, add drop $Co(NO_3)_3$ sol., heat again; gives pink color, when cool.

76. GROUP V.—Ba, Sr, Ca, Mg.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	SOL.
1. Prevent pptn. of $\text{Mg}(\text{OH})_2$ and MgCO_3 . To sol. add AmCl sol., then AmOH .		(a) BaCl_2 , SrCl_2 , CaCl_2 , (AmCl) $_2$ MgCl_2
2. Ppt. BaCO_3 , SrCO_3 , CaCO_3 . To (a) add Am_2CO_3 sol., warm, filter, wash.	(1) BaCO_3 , SrCO_3 , CaCO_3	(b) (AmCl) $_2$ MgCl_2
3. Final test for Mg. To (b) add HNa_2PO_4 sol.	(2) AmMgPO_4	
4. Dis. BaCO_3 , SrCO_3 , CaCO_3 in HAc . Pour on (1) a little HAc and stir it.		(c) BaAc_2 , SrAc_2 , CaAc_2
5. Sep. Ba from Sr, Ca. To (c) add $\text{K}_2\text{Cr}_2\text{O}_7$ sol., filter.	(3) BaCrO_4	(d) SrAc_2 , CaAc_2
6. Ppt. SrCO_3 , CaCO_3 . Alkalize (d) with AmOH , add Am_2CO_3 sol., boil, filter, wash.	(4) SrCO_3 , CaCO_3	
7. Dis. SrCO_3 , CaCO_3 in HAc . Dis. (4) in little HAc and dil. it.		(e) SrAc_2 , CaAc_2
8. Sep. Sr and Ca. To (e) add very dil. Am_2SO_4 sol., shake, let stand 2 hours, filter, test fil.	(5) SrSO_4	(f) CaAc_2 , CaSO_4
9. Final test for Ca. Alkalize (f) with AmOH , add Am_2Ox sol.	(6) CaOx	

Supplementary. — 1. AmOH alone partially ppts. $\text{Mg}(\text{OH})_2$. AmCl forms with Mg salts sol. (AmCl) $_2$ MgCl_2 , on which Am_2CO_3 has no effect. A large excess must be avoided. Mg really forms a group by itself, with a separate re-agent. 4. HAc is used, instead of HCl , as $\text{K}_2\text{Cr}_2\text{O}_7$ sol. ppts. Sr, Ca, as well as Ba from sol. in mineral acids. 5. Only a little of the sol. should first be tested for Ba. If present, the whole must be treated, but if Ba is absent, the rest may at once be tested for Sr (by 8). 5. BaCrO_3 must be removed (by repeated filtration if necessary) to prevent interference with Sr test. 6. SrSO_4 is slightly sol. in $\text{K}_2\text{Cr}_2\text{O}_7$ sol., hence it is better to re-ppt. Sr and Ca as carbonates, and re-dis. by HAc before adding Am_2SO_4 . 8. Very dil. Am_2SO_4 must be used to ppt. Sr, or Ca will be thrown down with it, as CaSO_4 is sol. in 400 pts. H_2O . The sol. of Am_2SO_4 should be tested with Ca sol. of a given strength, and if after 2 hours no ppt. forms it is sufficiently dilute. 9. All Sr must be ppd. before testing for Ca. Make separate sols. of SrSO_4 , CaSO_4 , MgSO_4 . (a) Try BaCl_2 sol. with each. (b) Try SrCl_2 sol. with each of the last two. (c) Try CaCl_2 sol. with the last. Explain the results.

77. SODIUM, Na'.

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.
1. Ppt. Na_2SiF_6 (v. Am, K). To a part of sol. add H_2SiF_6 sol.	(1) Na_2SiF_6	white
2. Inaction of H_2Tr on Na salts (v. Am, K). To part of original sol. add H_2Tr .	No ppt.	
3. Inaction of H_2PtCl_6 on Na salts (v. Am, K). To part of original sol. add a few drops of H_2PtCl_6 .	"	
4. Flame test for Na (v. K). Evap. part of original sol. to dryness, test with Pt wire in outer edge of Bunsen flame. Intercept flame with blue glass (or indigo sol. in t.t.). Hold sol. of $\text{K}_2\text{Cr}_2\text{O}_7$ in t.t. close to Na flame.		deep yellow colorless decolorized
5. Spectroscopic test for Na. Test flame as above, using a spectroscope, and compare with a chart (v. Physics).		yellow lines, etc.

Supplementary. — No ppt. is obtained with H_2SiF_6 unless the sol. is strong, hence this is not a very good test. What salts of Na are sol. (v. Table A)? Why should the original sol. be used in each case, e.g. in the flame test? Test the action of sol. Na salts on: (a) AgNO_3 sol.; (b) $\text{Pb}(\text{NO}_3)_2$ sol. Since Na salts are sol., explain the results.



ONS.

PPT.	COLOR.
(1) K_2PtCl_6	yellow
(2) $HgTr$	white
(3) K_2SiF_6	"
	red-violet
	blue lines, &c.

cause a ppt. from dil. sols.
 (a) Use several K salts
 In which is the flame test
 (b) Dist. by the flame
 test by H_4Tr sol.

79. AMMONIUM, NH_4^+ (or Am).

ANALYTICAL REACTIONS.

DIRECTIONS.	PPT.	COLOR.	SOL.
1. Ppt. Am_2PtCl_6 (v. Na, K). To a part of the sol. add a few drops of H_2PtCl_6 . Evap. and ignite (1).	(1) Am_2PtCl_6 (2) Pt (spongy)	yellow	
2. Ppt. HAMTr (v. Na, K). To some original sol. add H_2Tr and $\text{C}_2\text{H}_5\text{OH}$.	(3) HAMTr	white	
3. Generate NH_3. To some of original sol. (or solid) add NaOH sol., heat, and test gas (odor, litmus, HCl).			(a) NH_3 gas
4. Volatilization. Heat, and ignite on Pt foil.	No residue		
5. Nessler's test for NH_3. To part of original sol. add one or two drops of Nessler's sol.	(4) $\text{NH}_4\text{I} \cdot \text{Hg}_2\text{O}$	brown	
6. Inaction of H_2SiF_6 on Am salts (v. K, Na). To part of original sol. add H_2SiF_6 sol.	No ppt.		

Supplementary. — HAMTr will not ppt. unless a strong sol. is used. Test several compounds of Am by 3 and 4, e.g. AmNO_3 , Am_2O_3 , Am_2SO_4 , etc.

80. GROUP VI. — Na, K, Am.

Tests.	Results.
1. Test for Na. (a) To part of original sol. add H_2SiF_6 sol. (b) Apply flame test with Pt wire. (c) Apply spectroscope with Pt wire.	Na_2SiF_6. Yellow flame. Yellow lines.
2. Tests for K. (a) To part of original sol. add H_2PtCl_6 . (b) " " " " " " H_2Tr sol. (c) " " " " " " H_4SiF_6 sol. (d) Evap. part of original sol. and try flame test. (e) " " " " " " " " spectrosc. test.	K_2PtCl_6. HKTr. K_2SiF_6. Purple flame. Blue lines.
3. Tests for Am. (a) To part of original sol. add H_2PtCl_6 . (b) " " " " " " H_2Tr and $\text{C}_2\text{H}_5\text{OH}$. (c) " " " " " " NaOH sol., warm. (d) Evap. part of original sol. and ignite. (e) To part of original sol. add a drop of Nessler's sol.	Am_2PtCl_6. HAMTr. NH_3 gas. " $\text{NH}_4\text{I}, \text{H}_2\text{O}$.

81. BORATES, M_2BO_3 , $M_2B_4O_7$.

TESTS.	RESULTS.
1. Flame test. Mix a bit of powdered $Na_2B_4O_7$ (or other borate) with a drop or two of H_2SO_4. Dip a Pt wire (or glass rod) in this, and hold it in the edge of a Bunsen flame. The same test may be applied by putting the mixture in an e.d., stirring it with a little C_2H_5OH, and setting the latter on fire; or by mixing a drop or two of glycerin with it and testing with the Pt wire. H_3BO_3 gives a green flame without the use of H_2SO_4.	A green color is imparted to the flame.
2. Turmeric test. Add a <i>very little</i> HCl to a sol. of $Na_2B_4O_7$ till it is just acidified, then moisten a piece of turmeric paper with it.	The color of the paper is red-brown. On drying, the color becomes deeper red.

Supplementary. — Phosphates, salts of Cu and of Ba, except $BaSO_4$, also give a green flame, as does C_2H_5Cl (formed by C_2H_5OH and MCl). In testing for B, chlorids should first be removed by $AgNO_3$, and also Cu by H_2S . H_2SO_4 reduces salts of Ba to $BaSO_4$ (which gives no green flame), and the flame of phosphates is a very feeble green. H_3BO_3 in sol. should be evaporated, after first making alkaline to prevent volatilization.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$AgNO_3$	$Ag_2(BO_3)_2$	white		With normal borates. M_2BO_3 also give Ag_2O (brown).
2	$PbAc_2$	$Pb(BO_3)_2$	"		
3	$CaCl_2$	$Ca(BO_3)_2$	"	AmCl, acids	Not ppd. if dil.
4	$BaCl_2$	$Ba(BO_3)_2$	"	" "	" " " "
5	$Al_2(SO_4)_3$	$Al(OH)_3$	"	Acids	
6	$MgCl_2$	$Mg(BO_3)_2$	"	AmCl, acids	

82. NITRATES, MNO_3 .

TESTS.	RESULTS.
1. Copperas test (v. MNO_3). Mix in a t.t. a sol. of MNO_3, or sol. to be tested, with a fresh sol. of FeSO_4. <i>When cold</i>, introduce into the bottom of the tube, with a glass tube used as a pipette, a little H_2SO_4.	$(\text{FeSO}_4)_2\text{NO}$. Brown ring or halo at junction of liquids.
2. Deflagration test (v. MNO_3, MClO_3). Heat B.B.C.C. a very little powdered MNO_3; or mix with powdered charcoal, and put into an i.t. enough to cover a penknife point. Heat cautiously.	Vigorous deflagration ensues.
3. Red fumes test (v. MNO_3). Put into an i.t. very little MNO_3, heat. Insert a glowing splinter into the tube while heating.	NO_2 and N_2O_5 (red); O (colorless). Splinter burns.
4. Free HNO_3. (a) Add a little indigo sol. (b) Put a drop on the finger-nail, or dip a feather into it. (c) Pour a little on Cu and warm it.	Decolorizes, changing to red isatin. Turns animal matter yellow. Red fumes (NO_2), green liquid, $\text{Cu}(\text{NO}_2)_2$.

Supplementary. — If a ppt. appears on adding H_2SO_4 , let it settle, then decant. H_2SO_4 liberates HNO_3 from nitrates, and FeSO_4 reduces HNO_3 at the surface of contact to NO, which unites with FeSO_4 . Let it stand an hour or more if necessary. Heat decomposes this compound $(\text{FeSO}_4)_2\text{NO}$, expelling NO. The depth of color indicates the strength of nitrate. Heat decomposes all nitrates; from those of the alkali and alkaline earth metals are first formed MNO_3 and O, then M_2O , O, N. Nitrates of Ag and Hg reduce to the metal, others to the oxid only. KNO_3 and NaNO_3 show faint fumes, best seen by looking down the tube to a white background. Indigo is also decolorized by Cl, Br, etc. Nitrates of Au and Sb are unknown. All nitrates are soluble except $\text{Bi}(\text{NO}_3)_3$, which reacts with H_2O and ppts. $\text{Bi}(\text{OH})_2\text{NO}_3$ (variable), and to a less extent Hg , Hg'' , Sn'' , Sn^{iv} .

83. NITRITES, MNO_2 .

Tests.	Results.
1. Cupperas test (v. MNO_2). Apply this as in MNO_2 .	Same result as in MNO_2 , but more readily obtained.
2. Red fumes test (v. MNO_2). To a little MNO_2 add a few drops of H_2SO_4 . Test the HNO_2 formed with iodo-starch sol. Test it also with KMnO_4 sol.	NO_2 (red fumes) copiously evolved; also HNO_2 . Starch iodid (blue) formed. Decolorized.
3. Iodin test. Add a few drops of KI sol. to 3 or 4 cc. H_2O , then a few drops of dil. H_2SO_4 ; finally a little MNO_2 sol. (or substance to be tested). Test yellow liquid with starch sol.	HI first formed, then H_2O , and I set free by MNO_2 (yellow color). Iodid of starch (blue).
4. Nitrate test (v. General Reactions).	

Supplementary. — Indigo sol. is decolorized by nitrites, but not by nitrates except by the addition of H_2SO_4 , which forms HNO_2 . Apply the test. All nitrites are soluble, but AgNO_2 and $\text{Pb}(\text{NO}_2)_2$ only slightly. Hence this test cannot be applied in dil. sols.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AgNO_2	AgNO_2	white	{ Acids, H_2O (ex.)	This distinguishes MNO_2 from MNO_3 .
2	$\text{Pb}(\text{NO}_2)_2$	$\text{Pb}(\text{NO}_2)_2$	"	"	" " " " "

84. CHLORATES, MClO_3 .

TESTS.	RESULTS.
1. Oxygen test (v. MNO_2, MNO_3). Heat a small quantity of the solid in a t.t. Test the O with a glowing splinter. Dis. the residue when cool, and test for MCl with a drop of AgNO_3 sol.	Melts, O escapes, MCl remains. Re-kindles vigorously. AgCl (white) ppta., sol. in AmOH .
2. Chlorin test (v. MNO_2, MNO_3). To a very little of the powder in a t.t. add with great caution a few drops of H_2SO_4 .	ClO_2 (green-yellow, of characteristic odor) liberated with explosive violence.
3. Deflagration test (v. MNO_3). Powder and heat B.B.C.C.	Deflagrates.
4. Bleaching test (v. MNO_2, MNO_3). To sol. of indigo add MClO_3 sol., and heat. Mix sols. of MClO_3 and H_2SO_3 , and add to indigo sol., without heating.	Turned red (isatin). " " "
5. Silver nitrate test (v. MAc, MNO_3). To sol. add a few drops of AgNO_3 sol.	No effect if the MClO_3 is pure.

Supplementary. — All chlorates are soluble. Sb, Sn, and Au have no known chlorates. The deflagration of chlorates is greater than of nitrates. (a) Test this by scratching different kinds of matches. A few drops of HCl added to a few crystals of MClO_3 , and heated, give ClO_2 and Cl , of characteristic odor. Heat liberates O with violence from chlorates, but the presence of certain oxides (e.g. MnO_2) causes it to be liberated more regularly, and at a lower temperature. Dist. (b) KClO_3 and KCl ; (c) KClO_3 and KNO_3 ; (d) KClO_3 and KNO_2 .

CO₂.

RESULTS.

...s (colorless) is formed,
...ch ppts. white CaCO₃
...lime water.

BaCO₃ falls, ppd. by
...gas, and dissolved with
...rescence by HCl.

...ame is extinguished.

...will act on any carbonate
...O₂ with a carbonate (e.g.
...ry or acid carbonate), as
Heat breaks up many of
...quires a red heat, and the
...ature of the Bunsen flame
...carbonates, as: (a) HAc;
...erating C. (d) Pass CO₂
...a boil. Dist.: (e) CO₂ and
...CO₂ and M₂Ox. Some
...nate, others the secondary,
...as Pb(OH)₂. Carbonates are

86. SULFIDS, M₂S.

TESTS.	RESULTS.
1. Acid test. To the solid (or sol.) add a little dil. HCl (or H ₂ SO ₄), and warm it. Test the escaping gas (odor, PbAc ₂ sol. on paper).	H ₂ S gas formed, with odor of sewer-gas. Black, metallic PbS formed.
2. Coin test. Put a drop of water on a silver coin, and on this a soluble sulfid (if insol., first fuse with Na ₂ CO ₃). (V. M ₂ SO ₃ , M ₂ S ₂ O ₃ , M ₂ SO ₄ .)	Coin is blackened by formation of Ag ₂ S.
3. Ppn. tests (v. General Reactions).	

Supplementary. — All sulfids, except those of the alkalis and alkaline earths are insol. in H₂O. Most are sol. in dil. acids. A few (FeS₂, HgS, CoS, NiS, etc.) are not acted on by acids, except aqua regia. In such cases H₂S may be made by nascent H, with the addition of a little Zn. No sulfid of Al or Cr is known. Oxidizing agents with sulfids tend to form sulfates, or to liberate S and SO₂. (a) Test several with HNO₃, or aqua regia. Metallic sulfids (including Am₂S) ppt. from sols. metals of the first four groups, except Cr and Al. H₂S ppts. only the first two groups.

GENERAL REACTIONS.

	RE-AGT.	PPT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
		With H ₂ S:	With Am ₂ S:			
1	Pb(NO ₃) ₂	PbS	PbS	black	Hot HNO ₃ (dil.)	
2	AgNO ₃	Ag ₂ S	Ag ₂ S	"	" " "	
3	HgNO ₃	Hg ₂ S	Hg ₂ S	"	aqua regia	Warming changes to HgS and S.
4	HgCl ₂	HgS	HgS	"	" "	First white, then yellow, red, black.
5	BiCl ₃	Bi ₂ S ₃	Bi ₂ S ₃	"	Hot HNO ₃ (dil.)	
6	CdCl ₂	CdS	CdS	yellow	" " "	
7	CuCl ₂	CuS	CuS	{ brown- black	" " "	
8	AsCl ₃	As ₂ S ₃	As ₂ S ₃	yellow	{ Am ₂ S ₃ (ex.), Am ₂ CO ₃	Alkaline sol. not pptd. with H ₂ S.
9	SbCl ₃	Sb ₂ S ₃	Sb ₂ S ₃	{ orange- red	{ Am ₂ S ₃ (ex.), HCl (hot)	Ppn. with Am ₂ S is imperfect.
10	SnCl ₂	SnS	SnS	{ dark- brown	" "	
11	FeCl ₃	none	FeS + S	black	Acids	
12	CoCl ₂	"	CoS	"	aqua regia	AmCl aids ppn.
13	NiCl ₂	"	NiS	"	" "	" " "
14	MnCl ₂	"	MnS	pink	Acids	Turns dark - brown. AmCl aids ppn.
15	ZnCl ₂	"	ZnS	white	"	AmCl aids ppn.

87. SULFITES, M_2SO_3 .

TESTS.	RESULTS.
1. Acid test. To the solid (or sol.) add a little HCl (or dil. H_2SO_4), and heat it. Test the escaping gas (odor, $K_2Cr_2O_7$ paper).	SO_2 gas is liberated, reducing $K_2Cr_2O_7$ to green $Cr_2(SO_4)_3$.
2. Zinc test. To the original sol. add Zn and dil. H_2SO_4 . Test the escaping gas (odor, PbAc ₂ paper).	H_2S is liberated, forming with PbAc ₂ black PbS.
3. Coin test (v. M_2S, $M_2S_2O_3$, M_2SO_4). Heat the solid B.B.C.C. <i>with</i> Na_2CO_3 , also <i>without</i> . Put res. on Ag coin on which is a drop of water.	Na_2S is formed, and on the coin black Ag_2S .
4. Oxidation test (v. M_2SO_4). To some of the original sol. add a little euchlorin (or HNO_3), and heat. Test the product with HCl and BaCl ₂ sol.	M_2SO_3 is oxidized to M_2SO_4 , and pptd. with BaCl ₂ as white BaSO ₄ , insol. in HCl.

Supplementary. — The alkaline sulfites are freely sol. in water. Most others are but slightly sol., or are insol. Sulfites are decomposed by acids (except H_2CO_3 , H_3BO_3 , H_2S). (a) Ppt. BaSO₃ with BaCl₂ sol., dis. in HCl, filter if necessary, then oxidize fil. with aqua regia, and try to dis. ppt. in HCl. Heat changes sulfites to M_2O and SO_2 ; also to M_2SO_4 and M_2S . (b) Make the tests. Sulfites are reducing agents. (c) Test action of SO_2 on FeCl₃ sol., then test sol. for Fe'' and Fe'''. (d) Test HgCl₂ with SO_2 , then test sol. for Hg' or Hg''. (e) Generate H in a t.t., and test the gas for H_2S with PbAc₂ paper, then add a few drops of Na_2SO_3 sol. and test again. (f) Bring together jets of SO_2 and H_2S . (g) Test the bleaching action of SO_2 sol. by putting in it a colored flower, or cambric. (h) Test with litmus sol. (i) Let some SO_2 sol. stand for a few days in an open rec., and apply the BaCl₂ and HCl test. (j) Try the action of SO_2 sol. on CaCO₃.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	BaCl ₂	BaSO ₃	white	HCl (dil.)	(V. M_2SO_4)
2	AgNO ₃	Ag ₂ SO ₃	"	HNO ₃ (dil.)	Boiling ppta. dark-brown Ag.
3	Pb(NO ₃) ₂	PbSO ₃	"	"	Not blackened on boiling (v. $M_2S_2O_3$).
4	FeCl ₃	Fe ₂ (SO ₃) ₃	red		Boiling forms green FeSO ₄ .
5	HgCl ₂	HgCl	white		Boiling reduces to gray Hg.

88. THIOSULFATES, $M_2S_2O_3$.

TESTS.	RESULTS.
1. Bulb-tube test. Heat the solid in a tube.	Sublimate of H_2O and S, and liberation of SO_2 .
2. Acid test. Add to the conc. sol. (or the solid) HCl (or H_2SO_4), warm. Test SO_2 (odor, K_2CrO_4).	S ppts. (white), SO_2 formed.
3. Reduction test (v. M_2SO_3). (1) To a sol. of starch and KI (made blue by Cl) add a sol. of $M_2S_2O_3$. (2) To a sol. of starch and KI (uncolored) add $M_2S_2O_3$ sol. with which a little euchlorin is mixed.	Decolorized. Uncolored, as Cl has oxidized $M_2S_2O_3$ to M_2SO_4 and HCl .
4. Coin test (v. M_2S, M_2SO_3, M_2SO_4). Fuse B.B.C.C., put on Ag coin with a drop of H_2O .	Coin is blackened (Ag_2S).
5. Precipitation tests. (V. General Reactions.)	

Supplementary. — Thiosulfates, if mixed in a mortar with chlorates, explode violently. They are strong reducing agents. They are mostly sol. in water, except those of Ba, Pb, Ag. Dist.: (a) $M_2S_2O_3$ and M_2S ; (b) $M_2S_2O_3$ and M_2SO_3 ; (c) $M_2S_2O_3$ and M_2SO_4 .

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$BaCl_2$	BaS_2O_3	white	Dil. acids	Acids ppt. S (white).
2	$AgNO_3$	$Ag_2S_2O_3$	"	$Na_2S_2O_3$ (ex.)	Boiling forms Ag_2S (black). Forms slowly on standing.
3	$PbAc_2$	PbS_2O_3	"	" "	Boiling forms PbS (black). Forms slowly on standing.
4	$HgNO_3$	$Hg_2S_2O_3$	"	" "	Boiling forms Hg_2S (black). Forms slowly on standing.
5	$FeCl_3$	$FeCl_2$			Acts as reducing agent.
6	$CaCl_2$	none			Dist. from M_2SO_3 .

89. FLUORIDS, MF.

TESTS.	RESULTS.
1. Glass-etching test. (1) Put a little powdered CaF_2 into a small lead dish, and mix with enough H_2SO_4 to make a thick paste. Cover the dish with a piece of glass (coated with wax if desired, and a design scratched on it) and let it stand in a warm place for several hours. Remove the wax by melting, and finally with a cloth wet with alcohol, naphtha, or turpentine. (2) Mix a little CaF_2 with HKSO_4, put into a small t.t., and heat. 2. Turbidity test. Mix a little CaF_2, SiO_2 and H_2SO_4, put into a t.t. and heat it, meantime holding in the tube on a s.r. (or in the loop of a Pt wire) a drop of H_2O. 3. Free HF in sol. Dip a brush into the liquid in a leaden dish, and mark out a design with it on a glass plate, going over it several times. Avoid getting any HF sol. on the flesh.	The glass will be etched where exposed to the fumes of HF, SiF_4 being formed. The tube will be roughened (or etched) by the HF. The water is rendered turbid by the SiF_4 gas, forming H_2SiF_6. The glass will be etched as above.

Supplementary. — Several of the fluorids are soluble. The most important compounds of F are CaF_2 and HF. The latter corrodes glass, porcelain, and all metals except Pb, Pt, and Au. CaCl_2 ppts. CaF_2 (transparent, gelatinous). BaCl_2 ppts. BaF_2 (white). CaF_2 , which occurs in the earth as fluorite or fluor-spar and cryolite, Na_3AlF_6 , a mineral found in Greenland, are the main sources of F compounds.

90. CHLORIDS, MCl.

TESTS.	RESULTS.
1. HCl test. Add H_2SO_4 to the solid in t.t., heat. Test gas (odor, color, NH_3).	HCl is liberated.
2. Cl test. Mix the solid with MnO_2 , add H_2SO_4 , heat. Test gas (odor, color, NH_3 , indigo paper).	Cl liberated, green - yellow; AmCl with NH_3 , indigo paper bleached.
3. Precipitation tests. (a) To sol. add AgNO_3 sol. Expose part to sunlight, add AmOH to the rest, then HNO_3 . (b) To sol. add HgNO_3 sol.; then AmOH . (c) To sol. add $\text{Pb(NO}_3)_2$ sol. boil with plenty of H_2O .	AgCl (white) ppts.; blackens in light; sol. in AmOH ; reppd. by HNO_3 . HgCl (white) ppts.; blackened by AmOH . PbCl_2 (white) ppts.; sol. in boiling H_2O .

Supplementary. — Most chlorids are soluble. Except.: Ag, Pb, Hg', Cu'. SbCl_3 , BiCl_3 , SnCl_2 decompose water, forming SbOCl , BiOCl , Sn_2OCl_2 . H_2SO_4 frees HCl from all chlorids, except HgCl and HgCl_2 (and not much from Ag, Pb, Sn chlorids). HgCl_2 sol. fails to ppt. PbCl_2 from $\text{Pb(NO}_3)_2$ sol. (a) Test the last statement. Dist.: (b) MCl and MClO_2 (cautiously); (c) MCl and MNO_3 . (d) Take 5s KClO_3 and divide into 2 parts. Dis. one in H_2O and add AgNO_3 sol. Heat the other a few minutes, then dis., and add AgNO_3 sol. Compare the results.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AgNO_3	AgCl	white	AmOH , etc.	(v. Exp. 49.)
2	$\text{Pb(NO}_3)_2$	PbCl_2	"	Hot H_2O	(v. Exp. 48.)
3	HgNO_3	HgCl	"	HNO_3	(v. Exp. 50.)

91. BROMIDS, MBr.

TESTS.	RESULTS.
1. Bromin test. Mix MnO_2 with the solid, add a little H_2SO_4 , heat. Test the gas by holding in it a paper dipped in starch-paste.	Br (red gas) is liberated. Colors starch yellow to orange.
2. Iodo-starch test. Liberate Br as above, and hold in it a paper dipped in a mixture of starch-paste and KI sol.	Br combines with K in KI, liberates I, which forms blue starch-iodid.
3. CS_2 test. To the sol. add a drop or two of CS_2 sol., and a drop of euchlorin, and shake it.	Br is liberated and absorbed by CS_2 , which is colored yellow.
4. Silver nitrate test. To sol. add a drop or two of AgNO_3 sol. Try to dis. part of ppt. in HNO_3 , another part in AmOH .	AgBr, yellow-white, ppts., insol. in HNO_3 , slowly sol. in AmOH .

Supplementary. — Bromids are soluble, except those of Ag, Hg', Hg'', Cu', Pb. BiBr_3 and SbBr_3 need acidulation. Dilute H_2SO_4 acts on bromids to form HBr; strong acid forms Br. (a) To a bromid sol. add euchlorin (very little), and note the color. (b) Dist. MBr and MCl. (c) Pour a little Br vapor into starch-paste, and shake. (d) Mix starch-paste and KBr sol. (very little), and add a drop or two of euchlorin.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOL.	REMARKS.
1	AgNO_3	AgBr	pale yellow	AmOH	Only slightly sol. in AmOH.
2	PbAc_2	PbBr_2	white	Hot H_2O	Less sol. than AgCl in H_2O .
3	HgNO_3	HgBr	yellow-white	KBr	

92. IODIDS, MI.

TESTS.	RESULTS.
1. Starch test. Mix MnO_2 with the solid, add H_2SO_4, heat, and test with cold starch-paste (v. Exp. 40).	Violet I vapor appears, which colors starch-paste blue.
2. CS_2 test. Add to the sol. a drop of CS_2 [or $(\text{C}_2\text{H}_5)_2\text{O}$], then 2 or 3 drops of euchlorin (avoid excess), and shake it well.	CS_2 dis. the I set free by Cl, and is colored violet at the bottom of the tube. NaOH destroys the color, forming NaI and NaIO_3 .

Supplementary. — Most iodids are sol., except Pb, Hg', Hg'', Au. Sb, Bi, Cu, Sn^{IV} iodids need acidulation, as they react with H_2O . The double iodids (KIAgI , etc.) are formed and dis. with excess of KI with salts of Pb, Ag, Hg. I may be liberated from an iodid by Zn and HNO_3 , HNO_2 being first formed. Euchlorin or bromin acts the same. Iodids are broken up by oxidizing agents more easily than bromids or chlorids.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	AgNO_3	AgI	yellow-white	KCy , $\text{Na}_2\text{S}_2\text{O}_3$	Insol. in HNO_3 or AmOH.
2	$\text{Pb}(\text{NO}_3)_2$	PbI_2	yellow	NaOH (ex.)	Dis. by HNO_3 .
3	HgNO_2	HgI	green-yellow	HgNO_2 (ex.)	" " "
4	$\text{Hg}(\text{NO}_3)_2$	HgI_2	yellow-red	$\text{Hg}(\text{NO}_3)_2$ (ex.)	" " "
5	$\text{CuSO}_4 + \text{H}_2\text{SO}_4$	CuI	white	H_2O (sl.)	Insufficient reduc. agent ppts. I.

(MAc).

RESULTS.

M (MAc), turns black, gives odor of $\text{C}_2\text{H}_4\text{O}$ (inflammable).

D (MAc), having characteristic odor, if heated, on.

C (MAc), heated, having characteristic

H (MAc), boiling ppts., red-brown Fe^{+++} .

$(\text{CH}_3)_2\text{O}$ evolved (intensely

Ag and Hg only partially.

A and M₂Tr; (b) MAc and M₂Ox.

and an acetate. (b) Test

for acetic acid. (d) Make

dis. Zn; (g) Fe. (h) If so,

ICy).

RESULTS.

is formed (very poisonous); odor of bitter almonds.

is formed, sol. in HCl, giving red $\text{Fe}(\text{CyS})_3$, sol. in FeCl_3 .

(sol. in MCy excess), $\text{Fe}(\text{OH})_2$, $\text{Fe}(\text{OH})_3$ formed, soluble in HCl, but ppg. $\text{Fe}_2\text{Cy}_{18}$, deep blue.

(white) ppts., sol. in hot HNO_3 , re-ppd. by HCl.

in reacting with cyanids, as they are FeCy_2 , and those of the alkalies whose solutions are alkaline. The alkaloids, forming double salts.

Dist.: (b) MCy and MAc;

the following equations indicate

(1) Fe_2SO_4 ; (2) $4\text{MCy} + \text{FeCy}_2 =$

(4) $2\text{Fe}(\text{OH})_2 + \text{H}_2\text{O} + \text{O} =$

$3\text{HCl} + \text{Fe}(\text{OH})_3 = \text{FeCl}_3 +$

The vapor of H Cy is a

As used in medicine the



95. TARTRATES, $M_2C_4H_4O_6$ (M_2Tr).

TESTS.	RESULTS.
1. Ignition test (v. M_2Ox , MAc). Heat in i.t. Take odor, note res.	Evolves fumes (white, then brown), CO_2 , with odor of burnt sugar, and black residue, M_2CO_3 , C.
2. H_2SO_4 test (v. MAc , M_2Ox). Heat in i.t. with little H_2SO_4 .	CO , CO_2 , SO_3 , C.
3. Mirror test. Add $AgNO_3$ sol. (to a neutral sol.). Almost dis. ppt. with $AmOH$, then heat gently in t.t.	Ag_2Tr (white) ppts. Mirror of Ag collects on the tube.
4. Acetic acid test (v. MAc , M_2Ox). Add to sol. $BaCl_2$ sol. Dis. the ppt. in HAc . Add to sol. $CaCl_2$ sol. Dis. the ppt. in $AmCl$ sol.	$BaOx$ is sol. in HAc . $CaOx$ forms, sol. in $NaOH$, re-ppd. on boiling.
5. Potassium chlorid test. Add KCl sol. and C_2H_5OH to the sol., stir with a glass rod.	$HKTr$ (white) ppts. from strong sols. only.

Supplementary. — Only the alkali tartrates are freely soluble, and the bitartrates of the alkali metals are much less so than the normal ones (v. tests for K and Am). Dist.: (a) M_2Tr and M_2Ox ; (b) M_2Tr and MNO_3 . (c) Make $HAmTr$. (d) Try the reducing action of H_2Tr on $K_2Cr_2O_7$ sol. (e) See whether $CaTr$ is sol.

96. OXALATES, $M_2C_2O_4$ (M_2Ox).

TESTS.	RESULTS.
1. Ignition test (v. M_2Tr, MAc). Heat the solid in an i.t. Test gas with $Ca(OH)_2$ sol., also combustion of CO . H_2Ox decomposes with very slight charring, and without res.	CO_2 , CO , M_2O form. On passing the gas through $NaOH$ sol. to remove CO_2 , CO burns with blue flame.
2. Acid test (v. MAc, M_2Tr). Heat the solid with H_2SO_4 (which absorbs the H_2O).	CO_2 , CO , M_2O form. Dil. HCl , HNO_3 or H_2SO_4 decomposes M_2Ox , forming H_2Ox .
3. Calcium sulfate test. Alkalize the sol. with $AmOH$, add a little $CaSO_4$ sol. Try to dis. part of the ppt. with HAc , the rest with dil. HCl .	$CaOx$ (white) ppts., sol. in dil. HCl without effervescence, insol. in HAc .

Supplementary. — On igniting oxalates, carbonates and CO first form, then oxides and CO_2 . Ag_2Ox and $HgOx$ (which easily decompose with heat) give the metals as a final product. Ag_2O decomposes with explosion. (a) Test several oxalates, first changing them to Ag_2Ox . At moderate temperature H_2Ox sublimes unchanged, except to give off its water of crystallization. Most oxalates are insoluble, except those of the alkali metals and Cr . HCl , HNO_3 , or H_2SO_4 forms H_2Ox from its salts. Oxalates are reducing agents, (b) (test with $KMnO_4$), and are almost all white in color. (c) Make several oxalates. (d) See whether H_2Ox will react with metals, *e.g.* Zn and Fe .

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.
1	$CaCl_2$	$CaOx$	white	HCl (dil.)
2	$FeSO_4$	$FeOx$	yellow-white	
3	$AgNO_3$	Ag_2Ox	white	
4	$Pb(NO_3)_2$	$PbOx$	"	$NaOH$, HNO_3

97. SILICATES, M_4SiO_4 , M_2SiO_2 .

TESTS.	RESULTS.
1. Acid test. To strong sol. add HCl; then evap. Add HCl, boil, decant; then add to res. NaOH sol., boil. 2. Fusion test (insol. silicates). Mix thoroughly 2 pts. dry K_2CO_3, 2 pts. Na_2CO_3, 1 pt. <i>finely powdered</i> M_4SiO_4 (e.g. slate, etc.), <i>fuse thoroughly</i> B.B.C.C. Pulverize, add H_2O, boil, filter. To fil. add HCl, boil, evap. to dryness. Try to dis. in boiling HCl, then in boiling NaOH sol. The SiO_2 may also be tested with CaF_2 and H_2SO_4 in a leaden dish (v. Exp. 28).	H_4SiO_4 (gelat., white) formed. Heat reduces to SiO_2, insol. in HCl; partially sol. in NaOH sol. K_4SiO_4, Na_4SiO_4, M_2O (M_2CO_3) are formed. First two are sep. by H_2O, and changed by HCl to H_4SiO_4, and by heat to SiO_2 (gritty); insol. in HCl, slightly sol. in NaOH.

Supplementary. — Silicates are insol., except those of the alkalis, which are somewhat soluble. Some are dis. by acids, but many are not. SiO_2 is insol., even in acids (except HF), and is also infusible in the blow-pipe flame, but is fusible in the oxyhydrogen flame. There are two varieties of silica, the amorphous and the crystalline. The former is sol. in NaOH or Na_2CO_3 , the latter not. In a bead of Na_2CO_3 at very high temperature, B.B., SiO_2 and all silicates fuse to a clear glass. They will not fuse in a bead of $HNaAmPO_4$. The best fusing mixture contains about half each of Na_2CO_3 and K_2CO_3 , the mixture melting at a lower temperature than either alone. Test SiO_2 .

98. FERROCYANIDS, M_4FeCy_6 .

TESTS.	RESULTS.
1. Ferrous test. Add to the sol. — acidified with HCl — a few drops of $FeSO_4$ sol.	White $K_2Fe_2Cy_6$ ppts., changing quickly to blue. Darkens by oxidation.
2. Ferric test. Add to the sol. $FeCl_3$ sol.	Prussian blue, $Fe_4Fe_2Cy_{12}$, ppts., sol. in H_2O_x (not HCl) to dark-blue liquid. NaOH changes to red-brown $Fe(OH)_3$.
3. Copper test. Add to sol. $CuSO_4$ sol.	$Cu_2Fe_2Cy_6$ (chocolate) ppts., insol. in HAc.
4. Silver test. Add to sol. $AgNO_3$ sol.	White $Ag_4Fe_2Cy_6$ ppts., insol. in HNO_3 or AmOH. Heated with HNO_3 the ppt. forms $Ag_2Fe_2Cy_6$ (orange-red), sol. in AmOH.

Supplementary. — Ferrocyanids are mostly insol., except those of the alkalis and alkaline earths (Ba slightly). Ferrocyanids represent ferrous compounds, ferricyanids are from ferric salts. The most important of the former is K_4FeCy_6 , "yellow prussiate of potash." Make several ferrocyanids by the following table.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$AlCl_3$	$FeCy_3 + Al(OH)_3$	white	NaOH	Forms slowly.
2	$SbCl_3$	$Sb_2Fe_2Cy_{12}$	"	"	
3	$BiCl_3$	$Bi_2Fe_2Cy_{12}$	"	"	
4	$CdCl_2$	$Cd_2Fe_2Cy_6$	"	HCl, NaOH	
5	$CaCl_2$	$K_2CaFeCy_6$	"	NaOH	
6	$CoCl_2$	$Co_2Fe_2Cy_6$	green	"	Becomes grad. gray.
7	$CuCl_2$	$Cu_2Fe_2Cy_6$	red-brown	"	
8	$FeSO_4$	$K_2Fe_2FeCy_6$	white-blue	"	Rapidly changes from white to blue.
9	$FeCl_3$	$K_4Fe_2Cy_{12}$	blue	"	
10	$Pb(NO_3)_2$	$Pb_2Fe_2Cy_6$	white	"	
11	$MgCl_2$	$Am_2MgFeCy_6$	"	"	With ammonium salts.
12	$MnCl_2$	$Mn_2Fe_2Cy_6$	"	NaOH, HCl	
13	$HgNO_3$	$Hg_2Fe_2Cy_6$	"	NaOH	
14	$Hg(NO_3)_2$	$Hg_2Fe_2Cy_6$	"	"	Changes to $HgCy_2$ and $Fe_2Fe_2Cy_{12}$ (blue).
15	$NiCl_2$	$Ni_2Fe_2Cy_6$	green-white	"	
16	$AgNO_3$	$Ag_2Fe_2Cy_6$	white	"	Changes to blue.
17	$ZnCl_2$	$Zn_2Fe_2Cy_6$	"	"	

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99. FERRICYANIDS, M_4FeCy_6 .

TESTS.	RESULTS.
1. Ferrous test. Add to some of the sol. $FeSO_4$ sol.	Turnbull's blue, $Fe_2Fe_2Cy_{12}$ ppts. insol. in acids. NaOH decolorizes it.
2. Ferrie test. Add to some of the orig. sol. $FeCl_3$ sol. Dilute if necessary.	No ppt., but dark-green to brown coloration.
3. Copper test. Add to some of the orig. sol. $CuSO_4$ sol.	Yellow-green $Cu_2Fe_2Cy_{12}$ ppts., insol. in HCl.
4. Silver test. Add to some of the orig. sol. $AgNO_3$ sol.	Orange $Ag_2Fe_2Cy_6$ ppts., sol. in AmOH, not in HNO_3 .
5. Zinc test. Add to some of the orig. sol. $ZnCl_2$ sol.	Orange $Zn_2Fe_2Cy_{12}$ ppts., sol. in HCl or AmOH.

Supplementary. — Ferricyanids are mostly insol., except those of alkalis and alkaline earths. Alcohol does not ppt. the ferricyanid of Na or K from sol., and this also dist. it from the ferrocyanid. Make the test. K_2FeCy_6 was formerly called red prussiate of potash.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$AgNO_3$	Ag_2FeCy_6	red-brown	AmOH	Blood-red sol. with AmOH and AmCl.
2	$BiCl_3$	$BiFeCy_6$	brown		
3	$CdCl_2$	$Cd_2Fe_2Cy_{12}$	yellow	AmOH, HCl	
4	$CoCl_2$	$Co_2Fe_2Cy_{12}$	red-brown	AmOH	
5	$CuCl_2$	$Cu_2Fe_2Cy_{12}$	yellow-green	"	Green to brown color. In conc. sols. only.
6	$FeSO_4$	$Fe_2Fe_2Cy_{12}$	dark-blue	"	
7	$FeCl_3$	none			
8	$Pb(NO_3)_2$	uncertain	dark-brown	"	Turns white eventually. (V. M_4FeCy_6 .)
9	$MnCl_2$	$Mn_2Fe_2Cy_{12}$	brown	"	
10	$HgNO_3$	uncertain	red-brown	"	
11	$Hg(NO_3)_2$	none			(V. M_4FeCy_6 .)
12	$NiCl_2$	$Ni_2Fe_2Cy_{12}$	yellow-green		
13	$ZnCl_2$	$Zn_2Fe_2Cy_{12}$	orange	AmOH, HCl	

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100. SULFATES, M_2SO_4 .

TESTS.	RESULTS.
1. Barium test. To a little of the sol. add $BaCl_2$ sol., decant, and to the res. add dil. HCl .	$BaSO_4$ ppts., which is insol. in HCl .
2. Coin test (v. M_2S , M_2SO_3 , $M_2S_2O_3$). Fuse some of the solid B.B.C.C. (r.f.) with a mixture of Na_2CO_3 . Place the product on a silver coin with a drop of water.	Na_2S is formed, which dis. in H_2O and forms black Ag_2S with Ag .
3. Insoluble sulfates. Fuse 1 part of the solid with 2 parts each of K_2CO_3 and $NaCO_3$ (in Pt crucible, if no Ag , Pb , or S is present). Dis. what of the product will dis. in H_2O , the rest, separately, in HCl . Test the former for SO_4 , the latter for M .	K_2SO_4 , Na_2SO_4 , M_2CO_3 are formed. The first two are sol. in H_2O , the last in HCl . The former contains the radical, the latter the metal of the original.
4. Free H_2SO_4. (1) Put a drop on paper, and evap. it high above a flame, or over a water-bath. (2) Put a few drops on sugar in an e.d. and evap. over a water-bath. (3) Evap. some H_2SO_4 nearly to dryness, and add a little C_2H_5OH .	The paper is pulped, rotted, or charred. Comp. with HCl , HNO_3 . Greenish-black substance is formed. C_2H_4 is liberated, which burns with a luminous flame.

Supplementary. — In the barium test use dil. HCl unless considerable water is present for strong HCl dis. a little $BaSO_4$, and also ppts. $BaCl_2$ from sol. What sulfates are insol.? (a) Prepare some $PbSO_4$, and test it as above in 3. (b) Show that $PbSO_4$ exists in commercial H_2SO_4 by diluting some with its vol. of water. (c) Make $CuSO_4$, and test it. (d) Test Na_2SO_4 for traces of Na_2SO_4 . Are most sulfates sol. or insol.?

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$BaCl_2$	$BaSO_4$	white	400,000 pts. H_2O	The only salt of Ba (exc. $BaSiF_6$) insol. in dil. HCl .
2	$Pb(NO_3)_2$	$PbSO_4$	"	$NaOH$, $AmAc$	C_2H_5OH aids pptn.
3	$SrCl_2$	$SrSO_4$	"	7000 pts. H_2O	Ppts. slowly in dil. sol.
4	$CaCl_2$	$CaSO_4$	"	400 pts. H_2O	No ppt. in weak sol.

101. CHROMATES, M_2CrO_4 .

TESTS.	RESULTS.
1. Borax bead test. Make a bead of $Na_2B_4O_7$ or HNH_4PO_4 with Pt wire, dip into sol., fuse in either flame. 2. Fpn. tests. Apply the first three tests below (General Reactions). 3. Hydrogen dioxid test. Acidulate the sol. with H_2SO_4, and add a few drops of dil. H_2O_2 sol. Then add ether, and shake. This will detect 1 part of chromate in 40,000 of water.	Glass, yellow-green when hot, emerald-green when cold. A blue compound is formed of uncertain composition, which the ether dis. and carries to the surface as a blue liquid.

Supplementary. — Most chromates are yellow, dichromates are red. Dichromates are confined to the alkali metals. $K_2Cr_2O_7$, etc., ppt. normal chromates, e.g. $PbCrO_4$, $BaCrO_4$ from sol. Pb and Ba salts. In both the normal and the dichromates Cr is a hexad, in *ic* salts it is a triad, in *ous* salts a dyad. What other salts are yellow? Acids change chromates to dichromates, alkalis reverse this. Reducing agents (nascent H, SO_2 , H_2S) change Cr^{VI} to Cr^{III} , chromate to chromic salts.

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$BaCl_2$	$BaCrO_4$	yellow	Dil. acids	Insol. in HAc.
2	$Pb(NO_3)_2$	$PbCrO_4$	"	$\{ HNO_3 (sl.),$ $NaOH (sl.)$	
3	$AgNO_3$	Ag_2CrO_4	dark-red	$\{ HNO_3 (sl.),$ $AmOH$	
4	$HgNO_3$	Hg_2CrO_4	"	$HNO_3 (sl.)$	
5	$HgCl_2$	$HgCrO_4$	orange	"	Ppt. ignited equals Cr_2O_3 , Hg, O.
6	$BiCl_3$	$Bi_2(CrO_4)_3$	yellow	"	
7	$CdCl_2$	$CdCrO_4$	"	"	
8	Acids	$M_2Cr_2O_7$	red sol.		
9	$H_2S + HCl$	$S + CrCl_3$	green sol.		Changed back by alkalis to M_2CrO_4 (yellow).
10	Am_2S	$Cr(OH)_3$	green	Acids	Warming forms SO_2 , ppts. $Cr_2O_3CrO_4$ (brown).
11	$C_2H_5OH + HCl$	$CrCl_3$	"		On boiling. Odor of aldehyde.

102. PHOSPHATES, M_3PO_4 .

TESTS.	RESULTS.
1. Molybdate test. To 1 or 2 cc. of sol. add a drop or two of HNO_3 , then add 3 or 4 cc. Am_2MoO_4 sol., and let stand.	$Am_3PO_4 \cdot 12MoO_3$ (var., yel.) ppta., sol. in M_3PO_4 (ex.) or in $AmOH$.
2. Magnesium sulfate test (v. As, Mg). To sol. add $AmCl$ sol., $AmOH$, $MgSO_4$ sol., gently warm, stir, let stand.	$AmMgPO_4$ (white, crystalline) ppta.
3. Iron test. To sol. add a drop of HAc , excess of $NaAc$ sol., and 1 or 2 drops of $FeCl_3$ sol.	$FePO_4$ (yellowish-white, gel.) ppta., sol. in $FeCl_3$ (ex.).
4. Cobalt test (v. SiO_2, Al). Heat the solid B.B.C.C., then on white infusible mass put a drop of $CoCl_2$ [or $Co(NO_3)_2$] sol., and heat again.	Residue becomes blue.
5. Silver nitrate test. To sol. add $AgNO_3$ sol.	Ag_3PO_4 (yellow) ppta., sol. in HNO_3 .

Supplementary. — All phosphates are insoluble except those of the alkali metals; hence sols. of the other metallic salts ppt. phosphates. Most phosphates are somewhat sol. in HCl . If insol. in H_2O , they should be dis. in dil. HCl , $AmAc$ (made from $AmOH$ and HAc) added, then $FeCl_3$ till all the phosphate is pptd. The fil. will now contain a chlorid of the original metal. This test applies specially to phosphates of Ba, Sr, Ca, Mg. (a) Apply the test to each. (b) Test bone-dust in this way. (c) Test samples of fertilizers. Phosphates (and also oxalates) of Ba, Sr, Ca, Mg, if present, may ppt. with Fe, Cr, Al by $AmOH$. To separate them dis. the ppt. in hot dil. HNO_3 , cool and add excess $NaOH$ sol., which ppts. only Fe and the phosphates (or oxalates). Dis. the ppt. in HNO_3 , add H_2Tr and $AmOH$, which in excess ppts. the phosphates and oxalates, dissolving the Fe. (For arseniates and arsenites, v. Exp. 58.)

GENERAL REACTIONS.

	RE-AGT.	PPT.	COLOR.	SOLVENTS.	REMARKS.
1	$Co(NO_3)_2$	$Co_3(PO_4)_2$	red	$AmOH$, acids	Insol. in HNO_3 .
2	$NiCl_2$	$Ni_3(PO_4)_2$	light-green	" "	
3	$BiCl_3$	$BiPO_4$	white	HCl	
4	$Cu(NO_3)_2$	$Cu_3(PO_4)_2$	blue-white	HAc	
5	$HgNO_3$	Hg_2PO_4	white	HNO_3	$HgCl_2$ gives no ppt.
6	$Hg(NO_3)_2$	$Hg_2(PO_4)_2$	"	Acids, Am salts	
7	$BaCl_2$	$Ba_3(PO_4)_2$	"	Dil. HCl	

wC = sparingly sol. in H_2O . Made sol. by HCl .
 N = sol. in con. HNO_3 .
 n = sol. in dil. HNO_3 .
 R = sol. in aqua regia ($HNO_3 + 3HCl$).
 I = insol. in water or acids.
 wN = sparingly sol. in H_2O . Made sol. by HNO_3 .

TABLE B. — Tube Reactions.

Put into a small i.t. (or a bulb tube) a little of the powder, and heat it. Refer the results to this table.

GASES.	SUBLIMATE, ETC.	FUSION.	RESIDUE.	INDICATION.
Red-brown, NO ₂ Yellow-gr. (rare) Cl				MNO ₂ , MNO ₃ (MCl) MBr MI
Red, Br Violet, I	Black			NH ₄ M ₂ SO ₄ , M ₂ SO ₃ , M ₂ S ₂ O ₃
Odor, NH ₃ ; HCl tests	White			M ₂ S
Odor, SO ₃ ; K ₂ Cr ₂ O ₇ test				(MCO) M ₂ CO ₃ , M ₂ Ox M ₂ Ox MClO ₃ , MNO ₃ , MO ₃
Odor, H ₂ S; PbAc ₂ test	Yel.-red, brown drops	x		AmNO ₃
Odor, Cy (flame crimson)				HgCl HgCl ₂
CO ₂ ; Ca(OH) ₂ test				As ₂ O ₃ Sb ₂ O ₃ HgO S
CO (flame blue)				As ₂ S ₃ HgI ₂ Hg HgS
O (splinter test)				Black, tarry, burnt sugar odor
N ₂ O " "	Hot: yellow. Cold: white White	x	All finally vaporizes	M ₂ Tr H ₂ Ox MAc
White, As ₂ O ₃ (odor)	Cryst. Heat and C = mirror	x		Bi ₂ O ₃ Fe ₂ O ₃
O (splinter test)	White, needles Metallic Hg Yel.-red-brown drops Hot: red. Cool: yel. Red when rubbed Gray; white if rubbed Black; red if rubbed	x x	Black, changing to red	PbO
				SnO ₂ ZnO
Heavy white	White cryst.			Org. opds. of Na, K, Am, Ba, Sr, Ca, Mg Opds. of alkalis, + Cl, NO ₃ , opds. of alk. earths
		x	No decomposition	

TABLE C. — Action with H₂SO₄.

Put a little of the powder into a t. t., and add a *few drops* of H₂SO₄. Unless violent action ensues (as with KClO₃) heat it, and observe especially the gas.

COLOR OF GAS.	ODOR.	REFERENCE.	REMARKS.	GAS.	INDICATION.
Violet	None	Exp. 92	Dark crystal. sublimate.	I	MI
Yellow	ClO ₂	" 84	Substance detonates violently.	ClO ₂	MClO ₂
Red-brown	NO ₂	" 82, 83		NO ₂ , N ₂ O ₄	MNO ₂ , MNO ₃
Red	Br	" 91		Br	MBr
None	HCl	" 90		HCl	MCl
"	Stifing	" 89	Etches glass.	HF	MF
"	H ₂ S	" 86	In tube open at both ends gives SO ₂ .	H ₂ S	M ₂ S
White	SO ₂	" 87	S not liberated.	SO ₂	M ₂ SO ₃
"	"	" 88	S is liberated.	"	M ₂ S ₂ O ₃
None	HAc	" 93		HAc	MAc
"	HCy	" 94		HCy	MCy
"	CO	" 96		CO	M ₂ Ox
"	None	" 10, 101	Kindles splinter.	O	MO ₂ , M ₂ CrO ₄
"	"	" 85	White ppt. with lime water.	CO ₂	M ₂ CO ₃

TABLE D. — Heat on Charcoal (B.B.C.C.).

With the round end of the forceps make a slight depression in a piece of charcoal, and put in a little of the powdered substance. With a mouth blow-pipe blow the flame against it, cautiously at first, afterwards strongly.

RESULTS.	INDICATIONS.
1. Substance melts and runs into the coal.	Salts of the alkalis, and some alkaline earths
2. Leaves white, infusible residue. Add to this a drop of CoCl_2 sol., and heat again. The color may be: Blue, Green, Pink.	
3. Coats charcoal: White, volatile, garlic odor, no globule. " " hard, brittle globule. " when cool, yellow when hot, no globule. " " " " " globule malleable, but difficultly formed. Yellow, globule easily formed, fusible, soft, malleable. Yellow (orange when hot), globule hard, brittle. Brown or red, no globule.	Al, SiO ₂ , M ₂ PO ₄ , Zn Mg As Sb Zn Sn Pb Bi Cd
4. Deflagrates.	MnClO ₄ , MnO ₂
5. Volatilizes.	Am
6. Gives odor. Choking (SO_2). Garlic.	S or M ₂ S As

TABLE E.

Heat on Charcoal with Na_2CO_3 (B.B.C.C., Na_2CO_3).

Blow the inner flame (r.f.) for some time against a mixture of the powdered substance, and dry, fine Na_2CO_3 , using charcoal, as in Table D.

METALLIC GLOBULE.	NO GLOBULE.	INFUSIBLE POWDER.	COLOR MASS.	SOLID RESIDUE.	INCORUSTATION.	INDICATION.
x				White, brilliant, malleable, non-oxidizable.	In strong o.f. red-brown.	Ag
x				Hard, brilliant, oxidizable, reddish-white.	B.B. volatile. Hot, orange; cold, lemon-yellow.	Bi
x				Red, malleable; oxidizes to black; green flame.		Cu
x				Easily formed, fusible, malleable, oxidizes to yel.	Hot, lemon-yellow; cold, sulfur-yellow; vol. B.B.; O flame blue.	Pb
x				White, malleable, difficultly formed, easily oxidized.	Hot, yellow; cold, white near assay; non-vol.	Sn
	x				White, volatile; light-blue flame; garlic odor.	As
		x			Red-brown (like peacock feather); vol. B.B.	Cd
x	(x)			White, brittle, oxidizable.	Hot, yel.; cold, blue-white; vol. B.B. pale green.	Sb
		x			Hot, yellow; cold, white. With $\text{Co}(\text{NO}_3)_2$ green.	Zn
			x	Infusible magnetic powder, white, gray, black.		Fe
			x	" " " " "		Co
			x	" " " " "		Ni
			x	Yellow mass.		Cr
			x	Green "		Mn

TABLE F.—Flame Reactions.

Fuse one end of a Pt wire into a short glass tube. Hold the wire in the outer edge of a Bunsen flame till the latter loses the yellow color at first imparted. Moisten the wire with H_2O or HCl , and dip it into a little of the salt, then hold it again in the flame, noting the color. Clean the wire with HCl and the flame.

FLAME COLOR.	REMARKS.	INDICATION.
1. Violet	Seen through blue glass looks red-violet; otherwise Na obscures it.	K
2. Bluish		As
3. Blue		Pb
4. Blue-green	Moistened with H_2SO_4 .	M_2PO_4
5. "	First blue, then green.	Cu, espec. $CuCl_2$
6. Yellow-green	Moistened with H_2SO_4 .	M_2BO_3
7. "	" " HCl .	Ba
8. Greenish	Very slight color.	Sb
9. Bronze-green	" evanescent.	MNO_2
10. Orange-yellow	Blue glass obscures the color.	Na
11. Orange-red	Obscured by Ba.	Ca
12. Crimson	" " "	Sr

TABLE G.—Bead Reactions.

Make a loop in the end of a Pt wire (Fig. 38, Exp. 45), moisten and dip it into some powdered borax, then hold it in the flame; repeat till you have a glass bead filling the loop. Test a weak sol. (or the *smallest bit* of powder) by bringing the bead in contact with it, then blowing the flame against it with a blowpipe.

OXIDIZING FLAME (o.f., outer).		REDUCING FLAME (r.f., inner).		INDICATION.
<i>Hot.</i>	<i>Cold.</i>	<i>Hot.</i>	<i>Cold.</i>	
Blue	Blue	Blue	Blue	Co
Yellow-red	Green	Green	Green	Cr
Green	Blue-green	Colorless	Red-brown	Cu
Yellow-red	Yellow	Bottle-green	Bottle-green	Fe
Violet	Violet	Colorless	Colorless	Mn
"	Red-brown	Gray, cloudy	Gray, cloudy	Ni

TABLE H. — Acid Radicals — Résumé.

SALTS.	OTHER RE-AGENTS AND RESULTS.			
	BaCl ₂	BaCl ₂ +HCl	AgNO ₃	AgNO ₃ +HNO ₃
M ₂ SO ₄	w.	w.	(w.)	
M ₂ SO ₄	w.		w.	
M ₂ S ₂ O ₈	w.		w.	
M ₂ CO ₃	w.		w.	
M ₂ CrO ₄	l.-y.		d.-r.	
M ₂ PO ₄	w.		l.-y.	
M ₂ AsO ₄	w.		ch.-br.	
M ₂ AsO ₃	w.		y.-w.	
M ₂ BO ₃	w.		w.	
M ₂ Ox	w.		w.	
M ₂ Tr	w.		w.	
M ₂ SiO ₄	w.		l.-y.	
MNO ₃	w.		w.	
MF	w.			
MCl			w.	w.
MBr			y.-w.	y.-w.
MI			y.-w.	y.-w.
MCy			y.-w.	y.-w.
M ₂ S			b.	b.
M ₂ FeCy ₆			w.	g-br
M ₂ FeCy ₆			o.	o.
MNO ₂				
MClO ₃				
MAc				

For further explanation, v. Exps. 81-102. — Abbreviations: b. black, bl. blue, br. brown, ch. chocolate, d. dark, g. green, l. light, o. orange, r. red, v. violet, w. white, y. yellow.

Pb(NO₃)₂: w. SrCl₂: w. B.B.C.C. with Na₂CO₃ on Ag: b.
BaCl₂ + HCl + Cl: BaSO₄. HCl: SO₂ [odor, K₂Cr₂O₇: g.].
BaCl₂ + HCl: S. HCl: S + SO₂ [odor, K₂Cr₂O₇: g.].
HCl: CO₂ [Ca(OH)₂: w.]. Heat: (M₂O, CO₂).
Pb(NO₃)₂: y. HgNO₃: d.-r. HgCl₂: o. BiCl₃: y.
Cd(NO₃)₂: y. H₂S: y. Acids: r, which y. by alk.
AmCl + AmOH + MgSO₄: w. HNO₃ + Am₂MoO₄: y. B.B.C.C. + Co(NO₃)₂: bl.
H₂S, warm: y. AmCl + AmOH + MgSO₄: w. B.B.C.C.: As [garlic odor, white fumes].
H₂S + HCl: y. CuSO₄ (neutral): g. K₂CrO₄ + heat: g. KMnO₄: decol. C.C. + heat, t.t.: mirror.
H₂SO₄, Pt wire: green flame. Turmeric paper + H₂BO₃: br. H₂SO₄ + C₂H₅OH: green flame.
SrCl₂: w. CaCl₂: w. [sol. in HCl, insol. in HAc]. Heat: CO, CO₂, M₂CO₃, M₂O or M, no charring. H₂SO₄: effervesc., CO₂.
CaCl₂: w. [sol. in NaOH]. KCl: w. Heat: chars [odor]. AgNO₃ + AmOH: Ag mirror.
HCl + heat: SiO₂. Na₂CO₃ bead: effervesc., forms glass. HNaAmPO₄ bead: insol. B.B.C.C. + HCl, evap.: SiO₂, sol. in NaOH.
H₂SO₄: NO₂. HAc + KMnO₄: decol. HAc + AgNO₃: w. HAc + KI + starch: bl.
H₂SO₄ + heat: etches glass, makes H₂O turbid. HKSO₄ + heat: green flame.
H₂SO₄: HCl. H₂SO₄ + MnO₂: Cl. AgNO₃: w. [sol. in AmOH, action of light]. Pb(NO₃)₂: w. PbAc₂: w. CS₂ + Cl: y. H₂SO₄ + MnO₂: Br [starch, KI + starch].
Pb(NO₃)₂: y. HgNO₃: y.-g. HgCl₂: y.-r. CS₂ + Cl: v. H₂SO₄ + MnO₂: I [starch test].
CuSO₄: y.-g. Co(NO₃)₂: w.-br. NiCl₂: y.-g. H₂SO₄: H₂Cy [odor cautiously]. KOH + FeSO₄ + HCl: bl.
HCl: H₂S [odor, PbAc₂]. B.B.C.C. on Ag: b.
FeCl₃: bl. FeSO₄: bl.-w. CuSO₄: br.-r.
FeCl₃: r.-br. CuSO₄: g.-y.
Heat, i.t.: O, NO₂. B.B.C.C.: deflagrates. H₂SO₄: NO₂. FeSO₄ + H₂SO₄: r.-br. H₂SO₄ + indigo sol.: decol.
HCl + heat: g.-y. Heat, i.t.: O. H₂SO₄ (very little): Cl₂O₄ [y. gas].
Heat: blackens [odor]. H₂SO₄: HAc [odor]. H₂SO₄ + C₂H₅OH: C₂H₅Ac [odor]. FeCl₃, boil: r.

TABLE I. — Acid Radicals.

Arranged according to convenient method of detection.

1. **Flame** { H_3BO_3 ($\text{M}_3\text{BO}_3 + \text{H}_2\text{SO}_4$).
2. **Gas** { (with heat) { MNO_3 .
 { (with acid) { MNO_2 , MClO_2 , M_2CO_3 , M_2S , M_2SO_3 , $\text{M}_2\text{S}_2\text{O}_3$.
 { (with heat and acid) { MF , MCl , MBr , MI , MAc , MCy .
3. **Residue** { (with heat) { M_2Tr , M_2Ox .
 { (with heat and acid) { M_4SiO_4 (M_2SiO_2).
4. **Precipitate** { (iron-cyanids) { M_4FeCy_6 , M_2FeCy_6 .
 { (insoluble) { M_2SO_4 .
 { (unclassified) { M_2CrO_4 , M_2PO_4 , M_3AsO_4 , M_3AsO_3 .

COMPLETE ANALYSIS.

In making a *complete analysis*, i.e. analysis for the metal and acid radical, the following order should be observed, and the pupil should begin with only a single substance, such as $\text{Pb}(\text{NO}_3)_2$, FeCl_3 , etc., and should make a careful record under each head.

1. **External properties:** Color, luster, form (crystalline or amorphous), taste, odor, deliquescent, efflorescent, etc.
2. **Heat in glass tube** (v. Table B).
3. **Heat with H_2SO_4** (v. Table C).
4. **Heat B.B.C.C.** (v. Table D).
5. **Heat B.B.C.C. Na_2CO_3 (r.f.)** (v. Table E).
6. **Apply flame test** (v. Table F).
7. **Apply Borax bead test** (v. Table G).
8. **Test solubility** (v. Table A).
9. **Test for Metals** (aqueous analysis) (v. Exps. 48-80).
10. **Test for Acid radicals** (v. Tables H, I).
11. **State conclusion as to composition.**

